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FORM PTO-1390 U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE (REV 5-93)

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

		ATTORNEY'S DOCKET NUMBER 9083-6
		U S APPLICATION NO (If known, see 37 C F R 1 5) 09/647864
INTERNATIONAL APPLICATION NO PCT/AU99/00263	INTERNATIONAL FILING DATE 9 April 1999	PRIORITY DATE CLAIMED 9 April 1998

TITLE OF INVENTION

FLUID REGULATOR AND IMPROVEMENTS RELATED THERETO

APPLICANT(S) FOR DO/EO/US

Trevor CUNNINGHAM

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. [ ] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. [X] This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(l).

4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. [X] A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. [X] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] has been transmitted by the International Bureau. (courtesy copy enclosed.)
   c. [ ] is not required, as the application was filed in the United States Receiving Office (RO/US).

6. [ ] A translation of the International Application into English (35 U.S.C. 371(c)(2)).

7. [ ] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. [ ] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [ ] have been transmitted by the International Bureau.
   c. [ ] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [ ] have not been made and will not be made.

8. [ ] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. [ ] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. [ ] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. [ ] An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98.

12. [ ] An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. [X] A FIRST preliminary amendment.
    [ ] A SECOND or SUBSEQUENT preliminary amendment.

14. [ ] A substitute specification.

15. [ ] A change of power of attorney and/or address letter.

16. [X] Other items or information: International Preliminary Examination Report; Written Opinion; PCT Chapter II Demand; PCT Request; Reply to Written Opinion; International Search Report

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U.S. APPLICATION NO (If known, see 37 C F R 1 50)	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/647864	PCT/AU99/00263	9083-6

	CALCULATIONS	PTO USE ONLY
17. [X] The following fees are submitted: **Basic National Fee (37 CFR 1.492(a)(1)-(5)):** Search Report has been prepared by the EPO or JPO . . . . **$860.00** International preliminary examination fee paid to USPTO (37 CFR 1.482). . . . . **$690.00** No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) . . . . **$710.00** Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO. . . . . **$1000.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4). **$96.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT = **1000.00**	**$1,000.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than [ ] 20 [X] 30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	31-20 =	11	**X $18.00**	**$ 198.00**	
Independent Claims	31-3 =	28	**X $80.00**	**$2,240.00**	
Multiple dependent claim(s) (if applicable)			**+ $260.00**	**$**	
TOTAL OF ABOVE CALCULATIONS =				**$3,438.00**	
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 CFR 1.9, 1.27, 1.28).				**$**	
SUBTOTAL =				**$3,438.00**	
Processing fee of **$130.00** for furnishing the English translation later than [ ] 20 [ ] 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				**$**	
TOTAL NATIONAL FEE =				**$3,438.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				**$**	
TOTAL FEES ENCLOSED =				**$3,438.00**	
				Amount to be refunded	**$**
				charged	**$**

a. [X] A check in the amount of **$3,438.00** to cover the above fees is enclosed.

b. [ ] Please charge my Deposit Account No. ______________________ in the amount of $_________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 50-0220.

NOTE: **Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

SEND ALL CORRESPONDENCE TO:

David D. Beatty
Myers Bigel Sibley & Sajovec
Post Office Box 37428
Raleigh, North Carolina 27627

"Express Mail" mailing label number EL682671443US
Date of Deposit October 6, 2000

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1 10 on the date indicated above and is addressed to BOX PCT, Commissioner for Patents, Washington, DC 20231

Marjorie J. Pfeiffer
Marjorie J Pfeiffer
Date of Signature October 6, 2000

SIGNATURE

DAVID D. BEATTY
REGISTRATION NUMBER 38,071

09/647864
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Attorney Docket No. 9083-6 PATENT

IN THE UNITED STATES DESIGNATED OFFICE (DO/EO/US)

In re: Trevor Cunningham
Serial No.: To Be Assigned
Filed: Concurrently Herewith
For: FLUID REGULATOR AND IMPROVEMENTS RELATED THERETO

October 6, 2000

Box PCT
Commissioner for Patents
Washington, DC 20231

PRELIMINARY AMENDMENT

Sir:

Please enter the following preliminary amendment before calculating the filing fees and examining the present application:

In the Claims:

Please amend the claims as follows:

Please cancel Claims 2-5, 8-9, 11-16, 19-21, 23, 25-29, 31, 34-39, 41, 44-49, 51, 53-54, 56-57, 63-68, 71, 76-78, 80-82, 84-87, and 89-91.

REMARKS

Entry of this amendment, examination and allowance of the present application is respectfully requested.

Respectfully submitted,

David D. Beatty
Registration No. 38,071
Attorney for Applicant

Myers Bigel Sibley & Sajovec, P.A.
P.O. Box 37428
Raleigh, North Carolina 27627
Telephone: 919/854-1400
Facsimile: 919/854-1401

"Express Mail" mailing label number EL682671443US
Date of Deposit: October 6, 2000

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to BOX PCT, Commissioner for Patents, Washington, DC 20231.

Marjorie J. Pfeiffer
Marjorie J. Pfeiffer
Date of Signature: October 6, 2000

APPLICANT OR PATENTEE: ____________________

SERIAL NO. OR PATENT NO. ____________________ Attorney's Docket No.: ____________________

FILED OR ISSUED: ____________________

TITLE: ____________________

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(f) and 1.27(b)) - INDEPENDENT INVENTOR

As a below named inventor, I hereby declare that I qualify as an independent inventor as defined in 37 CFR 1.9(c) for purposes of paying reduced fees under section 41(a) and (b) of Title 35, United States Code, to the Patent and Trademark Office with regard to the invention entitled: ____________________ described in:

[ ] The specification filed herewith

[X] Application Serial No. ____________________, filed 6th October, 2000.

[ ] Patent No. ____________________, issued ____________________.

I have not assigned, granted, conveyed or licensed and am under no obligation under contract or law to assign, grant, convey or license, any rights in the invention to any person who could not be classified as an independent inventor under 37 CFR 1.9(c) if that person had made the invention, or to any concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e).

Each person, concern or organization to which I have assigned, granted, conveyed, or licensed or am under an obligation under contract or law to assign, grant, convey, or license any rights in the invention is listed below:

[ ] no such person, concern, or organization

[X] persons, concerns, or organizations listed below *

* NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities (37 CFR 1.27).

FULL NAME: Glenborden Pty. Ltd.
ADDRESS: Suite 5, 31 Broadway, Nedlands, Perth, Western Australia 6009

[ ] INDIVIDUAL [X] SMALL BUSINESS CONCERN [ ] NONPROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Trevor Cunningham		
NAME OF INVENTOR	NAME OF INVENTOR	NAME OF INVENTOR
X TREVOR CUNNINGHAM		
SIGNATURE OF INVENTOR	SIGNATURE OF INVENTOR	SIGNATURE OF INVENTOR
X [signature]		
DATE	DATE	DATE
12/12/00		

APPLICANT OR PATENTEE: ______________ Attorney's Docket No.: ______________

SERIAL NO. OR PATENT NO. ______________

FILED OR ISSUED: ______________

TITLE: ______________

VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
((37 CFR 1.9(f) and 1.27(c)) - SMALL BUSINESS CONCERN

I hereby declare that I am:

[ ] the owner of the small business concern identified below:
[X] an official of the small business concern empowered to act on behalf of the concern identified below:

NAME OF CONCERN: Glenborden Pty. Ltd.
ADDRESS OF CONCERN: Suite 5, 31 Broadway, Nedlands, Perth, Western Australia 6009

I hereby declare that the above identified small business concern qualifies as a small business concern as defined in 13 CFR 121.3-18, and reproduced in 37 CFR 1.9(d), for purposes of paying reduced fees under Section 41(a) and (b) of Title 35, United States Code, in that the number of employees of the concern, including those of its affiliates, does not exceed 500 persons. For purposes of this statement, (1) the number of employees of the business concern is the average over the previous fiscal year of the concern of the persons employed on a full-time, part-time or temporary basis during each of the pay periods of the fiscal year, and (2) concerns are affiliates of each other when either, directly or indirectly, one concern controls or has the power to control the other, or a third party or parties controls or has the power to control both.

I hereby declare that rights under contract or law have been conveyed to and remain with the small business concern identified above with regard to the invention entitled:

FLUID REGULATOR & IMPROVEMENTS RELATED THERETO

by inventor(s) Trevor Cunningham

described in:

[ ] the specification filed herewith.

[X] Application Serial No. ______________, filed 6th October, 2000.

[ ] Patent No. ______________, issued ______________.

If the rights held by the above identified small business concern are not exclusive, each individual, concern or organization having rights to the invention is listed below* and no rights to the invention are held by any person, other than the inventor, who could not qualify as a small business concern under 37 CFR 1.9(d) or by an concern which would not qualify as a small business concern under 37 CFR 1.9(d) or a nonprofit organization under 37 CFR 1.9(e). *NOTE: Separate verified statements are required from each named person, concern or organization having rights to the invention averring to their status as small entities (37 CFR 1.27).

FULL NAME: ______________
ADDRESS: ______________
[ ] INDIVIDUAL [ ] SMALL BUSINESS CONCERN [ ] NON PROFIT ORGANIZATION

FULL NAME: ______________
ADDRESS: ______________
[ ] INDIVIDUAL [ ] SMALL BUSINESS CONCERN [ ] NON PROFIT ORGANIZATION

I acknowledge the duty to file, in this application or patent, notification of any change in status resulting in loss of entitlement to small entity status prior to paying, or at the time of paying, the earliest of the issue fee or any maintenance fee due after the date on which status as a small entity is no longer appropriate (37 CFR 1.28(b)).

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

NAME OF PERSON SIGNING: BRIAN JOHN HOCKNEY.

TITLE OF PERSON OTHER THAN OWNER: DIRECTOR

ADDRESS OF PERSON SIGNING: 23 BELLEVUE TERRACE
SWANBOURNE. WA. 6010

SIGNATURE: B Hockney DATE: 1.12.00.

09/647864

19/prts.

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FLUID REGULATOR AND IMPROVEMENTS RELATED THERETO

FIELD

This specification discloses a number of inventions related generally to fluid flow and / or pressure regulation.

In one aspect, the present invention relates to fluid regulators, the control of pressure and/or fluid flow, and/or rate of flow and/or parts therefore.

In another aspect, the present invention has particular but not exclusive application to aerosols, trigger pumps, their actuators and/or nozzles and other fluid delivery mechanisms and/or containers.

In a further aspect, the present invention has specific application to actuators fitted to aerosols and may also be used in any application requiring fluid flow to be regulated to a near or substantially constant flow rate or pressure.

In a still further aspect, the present invention relates to a fluid regulator having an adjustable pressure and/or fluid flow, and/or rate of flow output which has particular but not exclusive application to the dispensing of agricultural chemicals and/or chemicals suspended in solution with carrier fluids such as, but not restricted to, water.

In yet a further aspect, the invention relates to a trigger pump or hand activated pumping means which is adapted in use to provide a relatively continuous flow. For the trigger pump, other features may be used singularly or in combination to improve operation such as an integral accumulator and fluid regulator which serve to deliver relatively continuous and/or regulated uniform pressure to a nozzle, thus allowing the nozzle to produce relatively continuous high quality spray with intermittent trigger pump action.

BACKGROUND

Pressure regulators typically incorporate several parts working together. Each part serves a particular purpose and therefore requires certain properties. Pressure regulators usually include a means of converting pressure changes into movement, such as a partition having an area open to pressure which is converted to a force; a biasing means such as a spring which moves relative to the force; a flow regulating device such as a valve; and a connection between

the partition and valve. An example given in US patent No. 5035260 and shown in Figure 1 of that patent is described below.

In figure 1 of the above US patent, but not illustrated in this specification, there is shown a line pressure regulator for a nozzle 10. The line pressure regulator comprises a housing 11 having an inlet 13 which opens into a first chamber 14 accommodated within the tubular body 12. The walls of the first chamber 14 are formed with a first port 15 and second port 16. The first port 15 opens to one side of a second chamber 18, while the second port 16 opens to another side of the second chamber 18 which in turn opens to the outlet 17 in the tubular body 12. Both sides of the second chamber 18 communicate through a fluid passageway 19 which provides a relatively unrestricted flow path. A spindle like support element 20 is received within the tubular housing such that it is axially slidable through the ports 15 and 16. The support element 20 supports a set of three valve members 21, 22, and 23 which are associated with the first, second and third ports 15, 16 and 24 respectively. The first valve 21 and second valve 22 are dimensioned so that they are slidably receivable through the first port 15 and second port 16 respectively with a very close tolerance therebetween. The end of the support element 20 adjacent the outlet 17 supports a valve member 23 which is sealingly engageable with a valve seat provided at the third port 24 when the support element 20 is located at an end position, at which position the line regulator is closed. The other end of the support element 20 is provided with an enlarged disc like head which is connected to a collapsible closure 26 extending between the periphery of the head 25 and a stop member 27 provided at the end of the tubular body 12. A pressure spring 28 is accommodated within the collapsible closure 26 between the face of the enlarged head remote from the other port 16, and the stop member 27. The stop member 27 is provided with a threaded stud 29 which bears against the end of the pressure spring adjacent the stop 27. The extent of the penetration of the stud into the stop 27 serves to vary the extent of the biasing force applied to the support element 20 by the spring 28. A portion of the support element adjacent the enlarged head 25 is formed with an increased diameter shank 30 which is snugly and slidably received by the flutes in the port

16 when the support element 20 is in its end position at which position the third valve member is in engagement with the third ports.

When no fluid pressure is applied to the inlet 13 and the pressure is insufficient to overcome the biasing force provided by the spring 28, the biasing force of the spring 28 ensures engagement of the third valve member 23 with the third port 24 to close the line regulator and prevent any fluid flow through the line regulator. On application of sufficient fluid pressure an axial force is exerted on the enlarged head member 25 adjacent the port 16 in opposition to the biasing force provided by the spring 28, and because the valve member 23 is smaller than the enlarged head member 25 the support element 20 is caused to move axially within the housing and the third valve member 23 disengages from the third port 24, allowing fluid to flow from the outlet. The commencement of fluid flow reduces the pressure on the enlarged head and balances the biasing force from the pressure spring 28. Should there be a rise in inlet pressure the degree of engagement increases thereby increasing throttling.

Partitions used in these pressure regulators have been made from materials such as rubber, which deforms easily and provides an effective seal against fluid leakage. The spring is normally a metal such as steel, which is resilient and has well known and repeatable deformation characteristics and is usually in the form of a coil spring. The partition covers the spring in such a way that when the pressure on the partition and support member increases, the spring and partition deflect. The rubber used in the partition is usually thin, as it is desirable that the spring characteristics should only come from the spring, not a combination of the spring and partition which may produce unpredictable or non-repeatable deformations.

Known types of pressure regulators usually need to handle corrosive fluids and have not been able to be constructed from a single type of material, as the requirements of the various parts were such that an appropriate material could not be found. As an example, the biasing, or initial pre-tensioning force of the spring required that the spring material not be subject to appreciable creep, and therefore a metal such as steel was required. The partition seals against the housing of the regulator, requiring a soft material such as rubber. The

valves need to be stiff enough to seal against the valve seats in the housing, but also needed to be easily constructed, therefore a substantially hard plastics material has been used. The different requirements for the materials resulted in many different parts being used to construct in-line regulators, increasing the manufacturing costs and requiring the further step of multi-part assembly.

Further, as the housing is typically a plastics material, there are limitations on the methods that can be used to attach the various materials to the housing.

A relatively large number of the world's aerosols use hydrocarbon propellants. The hydrocarbon partially liquefies with the product and is able, in use, to maintain a relatively low internal pressure. As the product is dispersed from the aerosol, some of the remaining propellent transforms from a liquid to a gaseous state in order to maintain the internal pressure. However, the hydrocarbon propellents used are considered to effect the atmosphere by adding to so called 'green-house' gases, and are also flammable, making the aerosol potentially dangerous if exposed to heat. Further, considerable problems exist with regard to freight and shipping because aerosols are considered by statutory bodies to be dangerous products.

Disposal of containers of aerosols having hydrocarbons as a propellant also poses a problem, in that although the propellant may be at or just above atmospheric pressure, the container has therein a flammable gas, discarded containers may pose an explosive danger, and recycling the container requires specialised equipment to ensure the containers are opened and crushed within chambers that capture the residual propellant.

From these, and other reasons, the aerosol industry would like to adopt an alternative technology, such as compressed rather than liquefied propellents. Further problems exist with compressed propellents, in that, in order to ensure that there is enough propellent in the aerosol to disperse all the aerosols contents, the aerosol is initially filled to have a relatively high internal pressure. As the product in the aerosol is dispersed, the internal propellent pressure reduces dramatically. This change in propellent pressure does not enable the aerosol product to be delivered with relatively consistent discharge characteristics, such as flow rate and/ or droplet size.

Pressure regulators can be used in the regulation of the outlet pressure and/or fluid flow from such devices as aerosol containers. An example of this type of regulator is disclosed in UK patent 2216634 and USA patent number 4,940,170.

Pressure regulators of this type typically incorporate a number of parts in a housing, such as a spring, a diaphragm, and a valve adjacent an outlet opening. Normally the valve is connected to the diaphragm, such that movement of the diaphragm, as modified by the spring, controls the flow of fluid through the valve in a self regulating fashion.

The above mentioned types of regulators may be used with aerosol containers, which are produced in very large numbers. It is therefore desirable to have the simplest and least expensive pressure regulator for controlling the output flow of fluid from the aerosol, or any other container.

Pressure regulators, such as those disclosed in the aforementioned patent, contain numerous parts. The parts are made of different materials, such as metal for the spring, plastic for the piston and rubber for the diaphragm and seals. Assembly of these parts is therefore difficult as there may be four or more parts, all of which are typically very small. Further, as the parts must fit with each other, the tolerances required in the manufacture of the parts become more critical as the number of parts increase. This is an important factor when parts must be assembled in large numbers, into a spray cap or housing for an aerosol container which is typically less than 20 mm in height and diameter. The components are relatively miniature and difficulty arises in handling and assembling them, particularly in a mass production environment, resulting in significant manufacturing and assembly problems.

Despite the ease of showing various springs and spindles in a drawing, the reality of manufacturing such components for use in, say aerosol actuators, and thus the requirement for miniaturisation, creates great problems for mass production. In aerosol containers in particular, it is desirable to have the pressure regulator fit into the actuator behind the spray nozzle and adjacent the inlet. The regulator is therefore required to be very small, and the movement of the valves and partition to also be very small, typically less than 1 mm. The

configuration of existing pressure regulators does not allow for easy miniaturisation as some parts cannot be shrunk proportionally and still function correctly or with sufficient accuracy, such as the spring and the partition. For example, due to the pressures to be regulated, there is a minimum thickness that the partition can be before it is susceptible to bursting.

In addition, these parts are designed to move with respect to each other and in response to pressure changes. Accordingly, parts whose dimensions fall outside the allowable tolerances cause the regulator to malfunction and not regulate the outlet pressure or fluid flow as would be desirable. As the number of parts increases, the tolerances of each part must decrease to ensure reliable operation when assembled. For example, if a valve must fit into a port to restrict fluid flow, the tolerance of manufacture of the valve must be added to the tolerance of manufacture of the port in order to obtain a total tolerance for the valve assembly. If this total tolerance is excessive, the valve assembly will not function correctly. This has found to be particularly important when balanced regulators, or regulators having two valves and two corresponding ports, are used. A bent spindle or just one of the valves not sealing with its respective port will severely reduce the ability of the regulator to function adequately.

As can be seen from the above, regulators are not easily transferable for use in an aerosol actuator as their shape is not appropriate.

In an agricultural application, when dispensing fluids such as fertiliser or pesticide, it is desirable that the amount dispensed per unit area be well controlled. A problem with dispensing such agricultural products is that commonly they are dispensed from a moving vehicle, such as a tractor, which will have a variable speed over the ground onto which the material is to be dispersed. As the speed of the vehicle varies, the fluid, which is typically dispensed from a vehicle at a constant rate per unit of time, will vary in its application rate and subsequent active chemical concentration per unit area over the ground. Typically, the vehicle will incorporate a boom having multiple fluid dispensers, and any change in speed in the vehicle will result in a wide area having a concentration of fluid per unit area different to that which is desirable. For example, if a tractor moves over the ground at 5 km/h, having a

10 metres wide boom dispensing a total of 10 litres of fluid per minute, then the amount of fluid dispensed is 12 ml per square metre. If the speed of the tractor rises slightly to 6.5 km/h, then the concentration of fluid per unit area will drop to 9.2 ml per square meter, which may not be sufficient.

In dispensing fluids, regulators incorporating flow regulating diaphragms may be used. Typically, these diaphragms have the fluid to be dispensed on one side, and a spring on the other. This method has been found to be suitable for regulating the flow of fluid close to a single desired output pressure and/or flow rate for a variable input pressure. However if it is desired to change the output pressure and/or flow rate, then usually the stiffness of the diaphragm or spring needs to be adjusted, which has been difficult to achieve.

A further problem in attempting to combat this problem is that the control mechanisms needed to vary the output of the regulators have been complex and expensive. Typically, a boom type dispenser may have 10 or more spray heads, and each one needs to be controlled accurately. In order to achieve this, costly regulating equipment has been used to date.

Further, trigger pumps currently in use require a person to repetitively and frequently squeeze the trigger to enable product to be dispensed from the nozzle attached to the trigger pump. The product so dispensed is dispensed at a variable pressure so that product is dispensed under a relatively low force initially, building to a relatively high force as the trigger is squeezed mid stroke, and during the period when the trigger is near the end of its stroke, the pressure available to dispense product diminishes relatively rapidly.

Nozzles used in conjunction with trigger pumps are designed with relatively consistent discharge characteristics, such as flow rate and/ or droplet size. Thus the pressure fluctuations experienced due to the operation of the trigger pump cause a great deal of variability in the discharge of the product being dispensed by the trigger pump.

Often the product used in trigger pumps includes chemical additives to enhance the products atomisation under the lower pressures that can be generated during at least part of the trigger pulling process. These additives are undesirable as they may be harmful to the environment, expensive, or take the

place of additional product which could be included in the trigger pump. The size of the particles generated during the atomisation process is dependant on the pressure differential across the outlet nozzle, and trigger pumps can generate an undesirably large range of particle sizes in a given squeeze of the trigger due to their wide fluctuating range of pressure generation. This can lead to relatively inefficient dispersal of the product as the droplet size may not be optimal for its intended purpose. For example, droplets that are too small tend to be influenced by air currents and are difficult to direct, while overly large droplets tend to fall out of the air and may not disperse as widely as desired, or may overly wet an object. Accordingly, it is desirable to be able to control the size of the particles being produced by the trigger pump. Further it is desirable for the nozzle of the trigger pump to produce droplets of a more uniform size.

SUMMARY OF THE INVENTION

Whilst the present specification relates generally to fluid flow and / or pressure regulation, the following disclosure will be made with reference to 5 general titles, namely "Diaphragm Regulator", "2-Part Regulator", "Aerosol", "Adjustable Regulator" and "Trigger Pump". Each invention disclosed has as an object to alleviate at least one prior art problem as outlined above.

DIAPHRAGM REGULATOR

In this aspect, the invention relates to what is called a 'spring diaphragm' being used in a fluid regulator. The spring diaphragm combines sealing and partitioning qualities of previously used components with the spring diaphragm's own resilient qualities, such as qualities inherent in the material used to make the spring diaphragm and / or the shape and configuration of the spring diaphragm, to impart a spring like operation when the diaphragm is in use. The use of a spring diaphragm leads to a reduction in the number of parts of the regulator, giving benefits such as a reduction in manufacturing costs, and/or in overall size of the regulator. Also, using of a spring diaphragm removes the need for a separate helical spring and allows a single material to be used for the spring and diaphragm function.

Desirably, the fluid regulator as disclosed above has an inlet chamber and an outlet chamber, wherein at least one valve is attached to a spindle and is

situated adjacent at least one corresponding port in the inlet chamber to restrict flow to the outlet chamber, such that there is minimal net force on the valve(s) from the inlet pressure of the fluid. The arrangement of the valves in the ports, such that there is minimal net force on the spindle, allows the removal of the spring biasing force if desired. The diaphragm may then be made from the same materials as the spindle and valves, such as, but not limited to, a plastics material. Thus all the internal parts of the fluid regulator may be made of the same material.

The present invention also relates to a method of regulating fluid flow by adjusting the clearance between at least one valve and corresponding port wherein the clearance between the valve and port is adjusted by a spring diaphragm having predetermined resilient characteristics. This leads to the removal of the spring, enabling the regulator to be made with fewer parts and to occupy smaller volume. Regulation may also be influenced by the shape or design of the diaphragm, such as slots or grooves for weakening and/or ridges or ribs for stiffening.

Preferably, one side of the spring diaphragm is exposed to the outlet pressure of the regulator and the other side is open to the atmosphere.

Typically the spring diaphragm is sealingly attached to a housing of the regulator. This prevents the unwanted leakage of fluid from the housing. This may be accomplished, for example, by an interference fit, glue, ultrasonic welding or other appropriate methods. The diaphragm may then be assembled quickly and easily in a way compatible with mass production of the regulators.

In another form, the present invention resides in a fluid regulator having a spring diaphragm which is substantially free of biasing force when no fluid is flowing. This allows the diaphragm to be free of the effects of creep, as there are no forces acting on the diaphragm for extended periods.

Preferably, the spring diaphragm described in the invention above has resilient properties. The diaphragm should be able to return to or near its original position after a short exposure to high pressure once the outlet pressure has returned to atmospheric, without appreciable permanent deformation or creep. When the fluid is flowing, the resilient properties of the diaphragm

provide a force which counteracts the force across the diaphragm from the outlet pressure. The opposing forces position the diaphragm in such a position that one or more valves connected to the diaphragm by a spindle regulate the flow of fluid from the outlet.

In one embodiment the fluid regulator, has a spring diaphragm and a spindle supporting one or more valve members of unitary construction. This allows the fluid regulator to be made with much fewer parts, thus enabling the regulator to be made smaller, as well as reducing manufacturing and assembly costs.

Preferably, the spring diaphragm is constructed from the same material as the valves and spindle. This obviously reduces material and manufacturing costs, while reducing assembly costs.

In another form of the present invention, a spring diaphragm may be attached to a housing of a fluid regulator via a collar situated at the outer periphery of the spring diaphragm. The use of a collar having an interference fit allows the spring diaphragm to be located in a sealing manner within the interior of the housing. This is relatively inexpensive and easy way to fix the spring diaphragm, however, without the collar, an interference fit would cause the spring diaphragm to deflect in the housing, thus effecting the position of the diaphragm in the housing and changing its deflection properties, effectively giving the diaphragm a preload.

Preferably, the collar has an outer surface which extends perpendicularly from the plane of the diaphragm, and a portion projecting from the collar which may be adapted to fit into a corresponding indentation in the housing, wherein the projecting portion is spaced laterally from the spring diaphragm which covers the interior of the collar. This arrangement allows the area of interference, ie the extending portion, to be spaced laterally from the portion surrounding the spring diaphragm. This allows the portion surrounding the spring diaphragm to be substantially stress free and therefore removes any preloading on the spring diaphragm.

The spring diaphragm may be in the form of a membrane such as a plate and optionally may include a number of annular or radial grooves. These

grooves can be used to set the stiffness of the diaphragm and therefore control the deflection of the diaphragm for a given pressure regulation range.

Alternatively the diaphragm may have a rippled surface.

The design of the surface of the diaphragm is determined by a number of factors including stiffness, strength, pressure differentials etc.

2-PART REGULATOR

In this aspect, the present invention relates to a fluid regulator including a diaphragm having an outlet aperture therein. This invention is based on the integration of a number of functions required in a regulated fluid delivery mechanism and allows the number of parts to be reduced and/or the overall dimensions of the regulator to be reduced. Preferably, the use of the spring diaphragm as disclosed above lends to the implementation of the present invention.

In another form, the present invention relates to a fluid regulator having a diaphragm, an outlet and a pressure chamber, wherein the diaphragm is situated on outlet side of the pressure chamber. Preferably, the outlet is within the diaphragm. This provides the advantage that the diaphragm regulates the pressure with respect to atmospheric pressure, while only requiring one aperture in the housing opening to the atmosphere. This reduces the number of parts of the regulator, and assists in the prevention of leaks. Further, if the diaphragm was situated distal from the outlet, the apparatus would be longer than necessary.

More preferably, the diaphragm is not sealed or enclosed. Accordingly, the number of parts is reduced, the diaphragm is, at least, partially open to the atmosphere, and the housing may be made smaller. Further, as the diaphragm incorporates the outlet aperture, a cover is unnecessary. The diaphragm of the fluid regulator described above, having an aperture, is preferably situated downstream from the valve.

Further, the present invention relates to a regulator for controlling flow of a fluid, consisting of a housing having an inlet and a diaphragm having an outlet, wherein a portion of the diaphragm and a portion of the housing form between them a pressure chamber, and fluid flows into the pressure chamber

through the inlet of the housing and out of the pressure chamber through the outlet in the diaphragm. This arrangement allows for a compact fluid regulator with relatively few parts.

The diaphragm may be operatively coupled to a valve which serves to regulate flow.

In another form, the present invention provides in combination, a spring diaphragm having an outlet therein and an aerosol or trigger pump as disclosed in this specification.

In another form, the present invention provides a three part fluid regulator, comprising a spring diaphragm, a valve and a housing (actuator).

In another form, the present invention provides a two part fluid regulator comprising a spring diaphragm including an outlet aperture and a port portion of valve means, and a housing including a body member defining a portion of an actuator and an integral spindle.

In another form, the present invention provides a two part fluid regulator comprising a spring diaphragm including an outlet aperture and an integral spindle, and a housing including a body member defining a portion of an actuator and a port portion of valve means.

In another form, the present invention provides a method of assembling an actuator, including connecting a spring diaphragm and a housing (actuator) together.

The present invention also includes a fluid regulator including a spring diaphragm having an outlet aperture therein. The use of a spring diaphragm reduces the number of parts and allows the component parts of the regulator to be made of the same material, such as a plastics material. Spring diaphragms also have the advantage that they have a spring rate which increases with deflection, thus reducing the instability of the fluid regulator at start up.

Preferably the outlet apertures described above contain a nozzle. This allows the diaphragm and outlet to be inserted into a housing as a unitary part, making assembly much simpler. Further, the assembly formed from such as arrangement is smaller, allowing the housing to be smaller, without the disadvantage that smaller parts are harder to assemble.

Further the nozzle, which aids the mechanical breakup of the fluid, may be formed by the outlet aperture being integral to the spring diaphragm and spindle so as to enhance atomisation at the point of discharge. This removes the need for a nozzle outlet insert, which allows for the further reduction of components to two, while still allowing the actuator to function effectively. This arrangement makes assembly simpler and more economical. A significant advantage of this approach is that the area of the spring diaphragm previously lost due to the nozzle insert may now be utilised, thus increasing the active area of the spring diaphragm. Alternatively, the spring diaphragm outside diameter may be reduced while still having sufficient working surface, therefore providing a further reduction in the overall size of the actuator.

AEROSOL

In this aspect, the present invention provides an aerosol including a compressed gaseous propellent, in which there is provided a fluid regulator to substantially regulate product dispersal flow.

The present invention is based on the realisation that the use of a fluid regulator in association with an aerosol having a compressed rather than liquefied gas propellant provides relatively consistent dispersal of aerosol product.

The compressed gaseous propellant mentioned above may include any gas and includes those gases that liquefy readily when compressed, such as chloro-fluorocarbons and hydrocarbons. However, it should be understood that the present invention is particularly useful for the use of gases such as air, nitrogen and carbon dioxide as a propellant.

It is to be understood that the words 'compressed rather than liquefied propellent' and 'compressed gaseous propellent' does not exclude the fact that the compressed propellent is capable of liquification. The propellant as herein referred to may also be a pressurised gas or fluid, not necessarily liquefied or compressed.

In one form, a balanced regulator of the type disclosed in US 5035260 may be used, however the regulator of the present invention can also be seen as a modification of the regulator disclosed in US 5035260, as the shut off valve

disclosed as a part of the US 5035260 regulator is not required in this invention.

The regulator of the present invention may be of any type of fluid regulator, one form of such regulator is disclosed above in the 2 Part Regulator. The present invention is also directed towards a regulator in an aerosol as described above in relation to the Diaphragm Regulator.

In one way, the present invention serves to operate on regulating generated pressure, that is, pressure already resident in an aerosol.

The present invention also includes a second aspect, namely an aerosol which includes an internal valve, such as a regulator (of any type) inside the aerosol container.

The second aspect is predicated on the realisation that by providing a valve internal of the aerosol container, it will be difficult, if at all possible, to refill aerosols. The internal valve may of the type disclosed herein, or may be a one-way valve.

A third aspect is directed to the present invention having a reduced number of parts as compared to prior art arrangements. This aspect is based on a balanced regulator for an aerosol actuator comprising a pressure surface, such as a diaphragm, connected to a spindle, the diaphragm being constructed from a material having spring like and sealing qualities, wherein the diaphragm is securely and sealingly attached to the actuator thus allowing the diaphragm and spindle alone to regulate the flow through the actuator. In one embodiment, the diaphragm and spindle are combined to form a single part. This enables the actuator to comprise two parts, being the diaphragm and spindle combination being slidably received into the housing of the actuator. Alternatively, the actuator may comprise three parts, wherein the diaphragm and spindle are separate parts which fit interlockingly together, and are slidably received into the housing of the actuator. In another alternative, the diaphragm and spindle may be made as one integral part.

In another form, the present invention includes a fluid regulator comprising a housing having an inlet and an outlet, said housing providing a first chamber open to the inlet, the first chamber being provided with a pair of substantially opposed ports which open to a second chamber, the second

chamber having a third port opening to the outlet, an axial support element movable through the pair of ports and received within the first and second chambers, the support element supporting a pair of valve members wherein a valve member is associated with each of the pair of ports, the support element being movable within the first and second chambers to vary the extent of engagement of the pair of valve members with the pair of ports, said support element further supporting a pressure surface at the other end which is in the second chamber, whereby the force exerted by fluid pressure in the second chamber on the support element counteracts the open or rest force applied thereto to move the support element from its rest position to a regulating position where the pair of valves are moved proximate their respective ports to vary the degree of opening of the ports in accordance with the fluid pressure applied at the inlet.

Preferably the support element and the pressure surface can be combined in one part.

Preferably, the support element is supported by fluted bearing guides which allow fluid to flow between the chambers.

Preferably, the chambers are connected by a passage allowing the communication of fluid.

Preferably, the regulator is provided in an actuator.

In one form the balanced regulator does not include a shut off valve.

In the present application, an actuator is defined as the apparatus which is used to enable or open the valve of the aerosol container. The actuator may also be the portion of the aerosol activated by an operator in order to enable dispersal of the aerosol's contents. The actuator is typically an attachment having a nozzle and a surface that may be depressed by the user. Further, an aerosol includes the container for the propellant and active constituent and other matter to be dispersed, including the actuator.

ADJUSTABLE REGULATOR

In this aspect, the present invention relates to an adjustable fluid regulator including a spring diaphragm, which controls the output of the fluid from the regulator, wherein one side of the diaphragm is exposed to the fluid

and the other side of the diaphragm is exposed to an adjustable source of pressure. This is based on the concept of changing the regulation characteristics of a regulator by applying an external biasing force.

Preferably the adjustable source of pressure is connected to one or more adjustable fluid regulators. This allows the control of a number of fluid regulators from a single source of pressure and a single controller, and thus has advantage (not exclusively) in agricultural applications.

Preferably, the adjustable fluid regulators are connected to a controllable source of variable pressure by conduits. This allows the adjustable fluid regulators to be controlled from a single point, whilst regulating the pressure and/or flow adjacent to fluid discharge points thereby eliminating potential pressure and/or flow drop due to fluid communicating gallery resistance, thus making the control easier and cheaper.

According to another aspect, this invention relates to an apparatus for controlling the rate of fluid flow from one or more fluid dispensers moving over a surface, in which there is, a fluid regulator, a sensor for detecting the speed of the dispensers over the surface, an adjustable pressure generator, and a control means,

wherein the regulator includes a diaphragm which adjusts the flow rate of fluid from the dispensers, and the sensor detects the speed of the dispensers over the surface and adjusts the pressure on one side of the diaphragm to control the rate of fluid flowing from the dispensers, dependant on that speed.

This invention is based on the concept of controlling the bias applied to a regulator in such a way that the regulator characteristics in operation serve to enable output of a dispenser in dependence of the speed of the dispenser over a surface, to provide a more even coverage.

This allows an easy, economical and fast method of controlling the output of an outlet in real time.

The present invention also provides a method of adjusting the rate of fluid flow from one or more dispensers having a diaphragm regulator wherein the speed of the dispenser over the surface varies, by measuring the speed of the dispenser relative to the surface, and varying the pressure on one side of the

diaphragm to control the output of fluid from the dispenser, to adjust and therefore compensate for the subsequent application variation.

In this way the fluid flow can be controlled to provide a more even coverage of fluid per unit area of surface.

Preferably there is more than one dispenser moving over the surface. This provides a wide surface coverage for a single pass.

More preferably, each dispenser has a regulator. This allows each dispenser to be regulated thus providing an even flow of fluid and thus the delay between varying the pressure behind the diaphragm and the fluid exiting the dispenser is reduced so as to enable appropriate adjustment during vehicle forward movement.

In another form, the adjustable fluid regulator includes a number of nozzle dispensers attached to a mechanism that allows the selection of an individual nozzle. As the present invention is to be used over a large range of fluid flow rates, it has been found to be advantageous to have a selection of nozzles to optimise the dispersal of the fluid over a range of flow rates.

TRIGGER PUMP

This aspect of invention provides a trigger pump which includes a means of producing a relatively continuous or more regulated flow output.

The invention stems from the realisation that a trigger pump serves to generate pressure, and that by providing a regulator in fluid communication with the trigger pump, a relatively uniform, regulated and/or prolonged output pressure may be provided, which in turn provides a relatively uniform, like that of an aerosol pressure pack, regulated and/or prolonged dispersal of product.

In this regard, the invention also provides a trigger pump and including a regulator in fluid communication therewith. Accordingly, the present invention advantageously provides an improved or more controlled droplet size, relatively independent of trigger squeeze pressure and/or frequency.

In a further improvement, the present invention seeks to provide a trigger pump with an accumulator having an output pressure reservoir. The accumulator may be a piston or sleeve accumulator. An output reservoir for pressure and/or product to be dispersed serves to enhance the time a product is

dispersed between pump activation(s).

In another form the trigger pump may be adapted to pressurise a container coupled thereto, which includes a regulator. Preferably the regulator is provided proximate the dispensing nozzle.

Alternatively, the regulator is provided to regulate and/or control the pressure and/or flow rate of fluid delivered to the container. In one form, the regulator is a balanced regulator.

The present invention also relates to a fluid regulator which may be used with a trigger pump. In one form, the present invention includes a fluid regulator comprising a housing having an inlet and an outlet, said housing providing a first chamber open to the inlet, the first chamber being provided with a pair of substantially opposed ports which open to a second chamber, the second chamber having a third port opening to the outlet, an axial support element movable through the pair of ports and received within the first and second chambers, a support element supporting a pair of valve members wherein a valve member is associated with each of the pair of ports, the support element being movable within the first and second chambers to vary the extent of engagement of the pair of valve members with the pair of ports, said support element further supporting a third valve member at one end which is associated with the third port, said support element being biased to an end position at which the pair of ports are open, and the third port is closed, said support element further supporting a pressure surface at the other end which is in the second chamber whereby the force exerted by fluid pressure in the second chamber on the support element counteracts the biasing force applied thereto to rapidly move the support element from its end position to a regulating position where the pair of valves are moved proximate their respective ports to vary the degree of opening of the ports in accordance with the fluid pressure applied at the inlet.

Preferably, when the support element is at its regulating position the third valve member is spaced clear of the third port such that there is substantially no throttling of the fluid flow through the third port.

In one embodiment the biasing force may be adjusted in order to adjust

the outlet pressure and/or flow rate of the fluid.

Preferably the support element and the flexible diaphragm are combined into one part. The diaphragm may be a spring diaphragm.

The support member may be supported in its axial movement by fluted bearing guides which allow fluid flow between galleries

In a further form, the present invention provides a method of fluid regulation for a trigger pump including the steps of:

passing fluid from one location to another location;

regulating or controlling the flow of the passing fluid by passing the fluid through a fluid regulator.

In a further form, the present invention provides a method of fluid regulation for a trigger pump including the steps of:

drawing fluid through a first pump chamber and one way valve into a second pump chamber;

pumping fluid from the second chamber into a pressure chamber having a one way valve, wherein the pressure chamber stores the fluid under pressure;

when the stored fluid attains a predetermined pressure, expelling the fluid from the pressure chamber through a regulator, wherein the regulator regulates the fluid flow from the trigger pump.

When compared to the prior art arrangements, such as US 4,940,170 the present invention(s) singularly or in any one or more combinations is considered to have the following significant advantages, without which the prior art arrangements are considered to lack commercial viability:

1. The present invention(s) disclose a spindle regulating face that is substantially flat with sharp edges and substantially parallel to the regulator shut-off port. This feature reduces the amount of spindle travel necessary to effect regulation. In combination with a plastic diaphragm / spring, this feature enables an adequate reduction of all of the mechanical disadvantages associated with this design combination so as to allow practical operation.

2. The present invention(s) disclose the use, within the diaphragm/spring, of relatively high stress small volume circular hinge like features in combination with relatively low stress large volume circular flap like features that result in

substantially reducing the total strain creep effect. This minimises regulation drift during the anticipated operational life of the actuator.

3. The present invention(s) discloses press-fit sealing of the diaphragm/spring collar to the actuator housing, wherein the surfaces of interference are displaced laterally away from its radial plane. This isolates the influence of the radial interference sealingly force fit from acting on the diaphragm/spring which consequently would effect the accuracy of the desired regulating volume.

4. The present invention(s) discloses substantial elimination of the internal galleries particularly the gallery behind the diaphragm/spring. This gallery reduction reduces the potential residual drip, after spray discharge termination.

5. The present invention(s) discloses an interference of the circumferences between the regulating face and the regulating port. This allows practical manufacturing whilst ensuring reliable regulation.

A number of other advantages are considered to be:

6. The present invention(s) discloses flutes or domed bearings located on the regulator spindle that provide axial guidance whilst not presenting significant restriction to fluid/product flow.

7. The present invention(s) discloses the diaphragm/spring as being uncovered thereby reducing the parts count by 1. OFF (i.e. Regulator minimum parts count 3. OFF - Spray Head minimum parts count 4. OFF).

8. The present invention(s) discloses placement of a regulator internal to an aerosol can which acts as a one way or non-return valve. This substantially prevents containers from being illegally re-filled.

9. The present invention(s) discloses an on/off valve and a fluid regulator which are operatively coupled within a single housing.

10. The present invention(s) discloses a throttling spindle that is integral with the actuator housing.

11. The present invention(s) discloses use with a trigger pump, whereas the Spray Head invention is directed for use with a can or container containing a liquid exposed to the pressure of a propellant.

12. The present invention(s) discloses use within a trigger pump of a first

manually operated pump chamber and a one way valve communicating with an accumulator, that stores excess or over pressure allowing continuous spray delivery, like that of an aerosol pressure pack, if desired.

13. The present invention(s) discloses a balanced throttling spindle with two regulating faces and a communicating bypass gallery between the diaphragm chamber and the nozzle outlet chamber, which reduces the net resultant force acting upon the spindle during operation, providing improved regulation accuracy.

14. The present invention(s) discloses several alternative spring diaphragm geometries.

15. The present invention(s) discloses a balanced double regulator in combination with a biased snap open / snap shut outlet poppet.

16. The present invention(s) discloses the rear face of the second regulating face as acting as the snap open / snap shut outlet poppet.

17. The present invention(s) discloses the addition of an internal or external spring as an alternative method to increase the regulation valve or to assist the initial biasing force for the poppet functionality.

18. The present invention(s) discloses a relatively simple resilient sleeve accumulator for use with a trigger pump.

DEFINITION

Throughout the present specification, the term fluid regulator is defined to mean an apparatus for the regulation and/or control of fluid flow, flow rate and/or pressure of fluid flow.

Throughout the present specification, fluid is taken to mean any substance or material capable of flowing, and includes, gases, liquids, solid particles suspended in liquids and flowable solids such as granules suspended in a liquid or gas.

PREFERRED EMBODIMENT

A preferred embodiment of the various inventions will now be described with reference to the accompanying drawings, wherein:

Figure 1 is a sectional side view of an aerosol actuator incorporating a fluid regulator of the present invention;

Figure 2 is a sectional side view of a second embodiment incorporating the present invention;

Figures 3a-3g are views of several embodiments of spring diaphragms in accordance with the present invention;

Figure 4 is a graph of force compared to deflection of a typical Bellville type spring diaphragm showing the regulating range for the present invention;

Figure 5 is a sectional side view of a fluid regulator of the present invention;

Figure 5a is a sectional side view of a unitary spring diaphragm spindle having an integral nozzle in accordance with the present invention;

Figure 5b is a sectional side view of an alternative fluid regulator of the present invention;

Figures 6a-6c are isometric views of the pressure regulator shown in figure 5;

Figure 7a is a sectional view taken along line B-B of the diaphragm and nozzle assembly of the fluid regulator shown in figure 7b;

Figure 7b is an end view of the regulator shown in figure 5;

Figures 7c and 7d are isometric views of views of the diaphragm and nozzle assembly of the fluid regulator shown in figure 5;

Figure 8 is a sectional side view of a second embodiment of the fluid regulator of the present invention;

Figure 9 is a sectional side view of a third embodiment of the fluid regulator of the present invention;

Figure 10 is an isometric view of the adjustable pressure regulator system of the present invention;

Figure 11 is a sectional side view of a dispenser of the adjustable pressure regulator system shown in figure 10;

Figure 12 is a close up of the dispenser of the adjustable fluid regulator shown in figure 10;

Figure 13 is a side view of the adjustable fluid regulator shown in figure 11, having two nozzles and a carousel;

Figure 14 is a sectional elevation of a first embodiment of the trigger

pump of the present invention;

Figure 16 is a sectional elevation of a second embodiment of the trigger pump of the present invention;

Figure 15 is an enlargement of a regulator and nozzle area of the trigger pump shown in figure 14;

Figure 17 is an enlargement of a regulator and nozzle area of the trigger pump shown in figure 16;

Fig. 18 is a graph of the relationship between pressure and displacement of a diaphragm of the regulator of the invention;

Fig. 19 is a schematic drawing of an alternative embodiment of an accumulator chamber of the present invention;

Fig. 20, 20a and 20b are graphs of the relationship between outlet pressure and time for the regulator of the present invention;

Fig. 21 is a sectional elevation of an aerosol cap incorporating a fluid regulator according to the first embodiment;

Fig. 22 is an enlarged view of the support element in position within the housing of the fluid regulator as shown in Fig. 21;

Fig. 23 is a sectional elevation of a second fluid regulator embodiment incorporated internally within an aerosol container;

Fig. 24 is a sectional elevation of the second fluid regulator embodiment incorporated internally within an aerosol container rotated 90°;

Fig, 25 is a schematic representation of the embodiment shown in Fig. 21; and

Fig. 26 is a graph of force in relation to deflection of a typical Bellville spring device for the present invention.

Throughout the specification, the reference numerals used in relation to the drawings firstly denote the drawing number and then the part number. For example, part '20' will be referred to as 520 in figure 5, and 720 in figure 7.

DIAPHRAGM REGULATOR

It is desirable to regulate the outlet pressure of, for example, an aerosol container in order to obtain consistent results in terms of flow rate or outlet pressure. This is particularly important for containers using pressurised gases

such as air or nitrogen where a full container is highly pressurised to start and drops significantly as the container is emptied. Existing aerosol containers normally contain a low boiling point propellant such as hydrocarbon, which liquefies at moderate pressure. This type of propellant provides a relatively constant internal pressure inside the container as the propellant evaporates, however hydrocarbons are not desirable as propellants for many reasons. Accordingly, a preferred embodiment of a pressure regulator in accordance with the present invention is described below.

A fluid regulator 110 is shown in fig 1. The regulator 110 includes a housing 112, an inlet 114, and an outlet 116. The inlet 114 is connected to the outlet 116 via ports 120 and 122 which communicate with chambers 124 and 126 respectively. Chamber 124 is connected to chamber 126 by a passage 130, and chamber 126 is adjacent outlet 116, allowing fluid to flow in a controlled way from the inlet 114, to the outlet 116.

Situated in the ports 120 and 122 is a support member such as spindle 132. The spindle 132 has valves 134 and 136 which fit into ports 120 and 122 respectively. The valves 134 and 136 have flutes 135 situated on the spindle 132 so that fluid may pass through the ports and the spindle 132 is supported by the ports. The end of the spindle 132 is connected to a spring diaphragm 140 by a ball 142 and socket 144 arrangement. It should be realised that the method of connection of the spindle to the diaphragm is not important to the present invention and any suitable method of attachment may be employed. Further the spring diaphragm 140 and spindle 132 may be of unitary construction enabling the combined structure to be formed from, for example, injection moulding, from a single material, such as a suitable plastics material.

As fluid enters the inlet 114 and flows past the valves 134 and 136 through the ports 120 and 122, the pressure in the chambers 124 and 126 builds up and acts on the diaphragm 140, causing the spring diaphragm 140 to move laterally, moving the spindle 132 laterally with it. The movement of the spindle 132 causes the valves to move into the ports 120 and 122 thus reducing the flow of fluid through the ports, and reducing the pressure in the chambers 124 and 126. This reduces the pressure on the spring diaphragm 140 and

causes the spindle 132 to retract increasing the clearance between the valves and the ports until an equilibrium position is established wherein the pressure from the fluid flow on the face of the spring diaphragm 140 matches the designed spring force acting against the pressure.

The spring diaphragm 140 combines the sealing and partitioning qualities of the prior art, with resilient qualities that were usually imparted by a coil spring. The combination of the separate spring and partition reduces part numbers and overall size of the components, especially as coil springs require a large working volume compared to a spring diaphragm. The spring diaphragm of the present invention has the added advantage that the spring rate is high and therefore the movement of the diaphragm from one pressure extreme to another is quite small, which is desirable in the present invention. This will be discussed in depth below.

The spring diaphragm 140 is shown in figure 1 in a condition where no fluid is flowing. The spring diaphragm is attached to the spindle 132 upon which the valves are located. The pressure on the spring diaphragm 140 adjusts the clearance between the valves and the ports to regulate the flow of fluid. As the fluid starts to flow the valves move toward the ports, (away from the outlet 116) and reduce the clearance. The resilient nature of the spring diaphragm 140 counteracts the force on the face of the spring diaphragm 140 to a certain degree so that flow from the ports is regulated.

After flow from the inlet has been stopped, the spring diaphragm returns to its original position.

As shown in figure 1 the spring diaphragm may be attached to the spindle 132 by a ball and socket arrangement. Alternatively, the spindle 132 including the valves and support flutes can be made integral with the spring diaphragm as seen in the spindle diaphragm member 210 in figure 2. This is particularly important if it is desirable to make these parts from a single material, such as a plastics material. Given the properties required of the spring diaphragm and spindle, a plastics material such as acetal has been found to be suitable.

The spring diaphragm may be attached to the housing in a number of ways. Advantageously the spring diaphragm is sealingly attached to the

housing. To assist in the seal between the housing 112 and the spring diaphragm, a collar 250 is provided as shown in figure 2, or collar 150 in figure 1. The collar acts to greatly increase the contact surface area between the spindle diaphragm and the housing, which increases the resistance to fluid leakage. Sealing means such as glue, ultrasonic welding or other appropriate methods may also be employed if desired.

A problem which has been encountered is that the use of an interference fit for attaching a diaphragm to the housing 112 places pressure on the diaphragm effecting its spring properties. Surprisingly, it has been found that if a collar which extends perpendicularly to the diaphragm as shown in figure 2 is used, the main region of interference, and therefore deformation of the collar 250, is moved laterally to be remote from the plane of the spring diaphragm 210. An interference fit can then be used without incurring the preloading or deformation problems of the collar 250. This arrangement allows the spring diaphragm 210 to be attached to the housing 112 without effecting the properties of the spring diaphragm 210.

Different embodiments of spring diaphragms are shown in figures 3a-3g. The spring diaphragm can be described as a plate with various modifying features. In this specification, the term plate is taken to encompass any flat, dished or curved section which may include any number of grooved or rippled forms on the surfaces of the diaphragm. The material that the plate may be constructed from is preferably a plastics material, but may be any suitable material such as a hard rubber, or thin metal.

An example embodiment of the present invention is also discussed in the disclosure below.

The arrangement of the spring diaphragm depends on the shape, profile and materials used in its construction, as shown in figures 3a-3g. The grooves employed can be used to concentrate forces in localised areas, to increase the flexibility and reactance without exceeding the elastics limits of the material being used.

Referring to figures 3a-3g, several different embodiments of an aspect of the present invention are shown. In figure 3a, a spring diaphragm 330 is shown,

integrally attached to the spindle 320 and having a collar 340. Given a predetermined pressure and displacement range for a material, the thickness T_1 of the spring diaphragm can be calculated. In spring diaphragm 330, the thickness of the diaphragm is uniform however thickness need not be uniform in all embodiments.

In order to increase displacement when the diaphragm is subjected to a given pressure, an area of reduced strength can be incorporated. This area of reduced strength can take many forms, for example using one or more annular grooves providing localised areas of reduced thickness, as shown at 341 in figure 3b and 338 in figure 3f. The areas of reduced thickness may also be in the form of radial grooves as shown at 343 in figure 3d.

An additional embodiment shown in figure 3c has a rippled spring diaphragm which may be of uniform thickness, or may include some of the weakened areas shown in the other embodiments. The ripples 342 in the surface allow the diaphragm to have an increased lateral deflection for a given pressure differential.

A further embodiment of the spring diaphragm, is based upon a bellville spring with characteristics as shown in figure 4. The bellville spring is stable until it is deflected beyond its flat profile after which it assumes an inverted rest profile. Initially when the outlet pressure is atmospheric, the bellville spring diaphragm 334 is in the position shown in figure 3e. As the inlet pressure increases, the distance D decreases, and the valve(s) begin to close, as in the previous embodiments. Under flow conditions, the bellville spring diaphragm 334 has a spring characteristic as shown in figure 4 between points 4A and 4B, which is not as steep as the rest of the curve, the result being that the lateral deflection of the diaphragm is relatively large for small variations in force.

In figure 3f there is shown a diaphragm 336 which includes one or a number of concentric rings or tubes 337 with a flexible attachment 338 therebetween. The flexible attachments 338 act like hinges with low radial stiffness, low bending stiffness and high axial stiffness. The small volume of material in these regions is allowed to operate at high stress. In doing so they attract only a small proportion of the total strain energy applied to the

diaphragm. The much larger volume concentric rings operate at a lower stress to reduce the effects of creep, because, due to their relative bulk, they absorb the majority of the total strain energy.

In figure 3g there is shown a diaphragm 335 which includes a number of circular corrugations 344 oriented axially to produce a bellows arrangement, which allows an increased axial movement while maintaining a more constant spring rate. The spindle 320, diaphragm 335 and corrugations 344 may all be made from the same material, such as a plastics material.

As an example, the current size of the Line Pressure Regulator, as described in US 5035260 has 7 parts plus 3 O-rings and is 70 mm long, and an average diameter of 22 mm, forming an envelope volume of 26,610 mm^3. This is obviously too large to be used as an actuator on an aerosol can.

The fluid regulator of the present invention, as shown in figures 1 and 2, includes only 3 or 4 parts and does not use O-rings. In fact, if the housing and nozzle are discounted, the present invention can be made from a single part. The present invention can be reproduced in an envelope volume of 2460 mm^3 or smaller. More importantly, the reduction of external size of the present invention is by a factor greater than 10, however, due to the features of the present invention the internal valve diameters have only been reduced by a factor of two. This enables the tolerances to remain acceptable for mass production and provides enough working volume for accurate pressure regulation, whilst precluding potential gallery blockage. The reduction in size of the present invention allows it to be used with an aerosol actuator.

Further, the reduction in size has been necessary to reduce the flow rate of the regulator, as it is desirable to have a flow rate of 50-100 ml per minute for aerosol applications, whereas the previous device had a flow rate of 200 -2000 ml per minute.

2-PART REGULATOR

The disclosure made herein is in respect of a single faced regulator, but the present invention has equal application in conjunction with other regulators, such as balanced regulators and/or snap open/snap shut regulators as disclosed in this specification.

It is desirable to regulate the outlet pressure of, for example, an aerosol container in order to obtain consistent results in terms of flow rate or outlet pressure. This is particularly important for containers of pressurised gases such as air or nitrogen or CO_2. Existing aerosol containers normally contain a propellant such as hydrocarbon, which liquefies at moderate pressure. This type of propellant provides a relatively constant internal pressure inside the container as the product is expelled and the propellant evaporates, however hydrocarbons are not desirable as propellants for many reasons. Accordingly, a preferred embodiment of a pressure regulator in accordance with the present invention is described below.

A fluid regulator 510 is shown in figure 5. The regulator 510 includes a housing 512, an inlet 514, an outlet 516, a pressure chamber 518 and a diaphragm 520. The diaphragm 520 is connected to a valve assembly 526 by a spindle 528. The valve assembly 526 includes a valve 530 in a port 532. The spindle 528 is supported in the port 532 by a number of guides 538. In the illustrated example there are four guides 538 distributed around the periphery of the spindle 528, which is typically cylindrical in shape, as shown in the cross section taken through the spindle 528 at section A-A. The guides 538 reduce the friction of the spindle 528 in the port 532, and also allow the free passage of fluid between the spindle 528 and the port 532, while supporting the spindle 528 in position.

Another embodiment of the spring diaphragm is shown in figure 5a, wherein the spring diaphragm 560 and spindle 562 are integral to form a spring diaphragm spindle 570. Also integral with the spring diaphragm spindle 570 is an aperture 572 adapted to form a nozzle 574. The nozzle assists in the break up of the fluid into appropriately sized droplets. The nozzle 574 is fed by channels 576. As can be seen in a comparison between the arrangements of the spring diaphragm 520 in figure 5 and spring diaphragm spindle 560 in figure 5a, the adaptation of the aperture to include a nozzle 574 has decreased the area of the spring diaphragm 560 lost due to the use of a press fit nozzle 534. The integration of the nozzle 574 and the spring diaphragm spindle 560 allow a reduction in part numbers and a reduction in the outer diameter of the spring

diaphragm while still achieving the same working surface area of the spring diaphragm.

The size and profile of nozzle 574 can be varied depending on various factors, such as required droplet size, outlet pressure or fluid characteristics.

In figure 5b, another embodiment of a fluid regulator 510b is shown, wherein when there is no fluid flowing, the spring diaphragm 520b is adjacent or close to the housing 512b, thus minimising the volume of the pressure chamber 518b. This in turn reduces the overall volume of the fluid regulator 510b. When fluid is flowing through the fluid regulator 510b, the spring diaphragm 520b moves away from the housing 512b, forming pressure chamber 518b therebetween.

Figures 6a-6c show isometric views of the pressure regulator shown in figure 5.

In figures 7a-7d, various views of the diaphragm 720 and spindle 728 are shown. The spindle 728 is integral with the diaphragm 720, as can be seen in figure 7d. Holes 744 in the diaphragm 720 provide a fluid passage connecting aperture 740 to the pressure chamber 718, thus allowing fluid to flow from the pressure chamber 718 to the outlet 716 and through nozzle 734. In the cross section of the diaphragm 720, spindle 728 and nozzle 734 taken along line B-B of figure 7b, the nozzle 734 can be seen in the aperture 740. In the embodiment shown, the nozzle 734 at the outlet 716 occupies a large proportion of the aperture 740. A projection 746 provides an appropriate gap between the nozzle 734 and the diaphragm 720, allowing fluid to flow from the holes 744 into the aperture 740 and out the outlet 716 through nozzle 734. The nozzle 734 may be made integral with the diaphragm if desired, or the hole/holes 744 could be used to function as a nozzle, depending on the fluid to be regulated and the application to which the fluid is put. The holes 744 could also form part or all of the aperture 740. There is no necessity for the regulator 710 to include a nozzle.

The diaphragm itself may be made from a material that allows the flow of the fluid from one side to the other, but also has sufficient resistance to flow in relation to stiffness to cause the diaphragm to move as fluid flows through it in

order to effectively actuate the flow control valve.

The diaphragm 520 may be attached in a substantially sealing manner to the housing 512 by ultrasonic welding, gluing, an interference fit or other appropriate method.

The diaphragm 520 also includes a number of weakened portions in the form of one or more circumferential grooves 542. These allow the central portion of the diaphragm 520 to pivot around the grooves 542 so that spindle 528 moves laterally the appropriate amount relative to the port 532. The working of the diaphragm is explained elsewhere in this specification.

In use, with reference to the embodiments shown in figures 5 and 7a-7d, an actuating surface 536 on the housing 512 is pressed downwardly, causing fluid to flow up out of the aerosol container 522, past the stem gasket 543, through the stem 524 and into the inlet 514. At the start of operation, the pressure in the chamber 518 will be atmospheric, and therefore the diaphragm 520 will be in a free position, that is, not subject to external stresses from fluid pressure. When the diaphragm 520 is in the free position, the spindle 528 connecting the diaphragm 520 to the valve 530 places the valve in an open position, allowing free fluid communication between the inlet 514 and the pressure chamber 518, through the port 532. As fluid flows into the pressure chamber 518, the pressure increases and causes the diaphragm 520 to move in a direction away from the port 532. This causes the connected valve 530 to move towards the port 532 reducing the gap between the port 532 and the valve 530. If the pressure in the pressure chamber 518 increases significantly, the valve will move to be closer to the port 532, thus substantially sealing the inlet 514 from the pressure chamber 518.

Simultaneous to the fluid flowing into the pressure chamber 518, the fluid also flows in a partially restricted manner through one or more holes 544 in diaphragm 520 and into aperture 540. Typically, a nozzle 534 is situated in the aperture 540 at the outlet 516, and fluid flows out of nozzle 534, causing the fluid to disperse, for example, into fine droplets. The pressure in the pressure chamber 518 is dependant on the relative flow rate of the fluid into the pressure chamber 518 past valve 530 and through port 532, compared to the flow rate of

the fluid out of the pressure chamber 518 through holes 544 into aperture 540 and out outlet 516 through nozzle 534. As fluid flows through aperture 540 to outlet 516, the fluid flow is further restricted through the nozzle 534, and there may also be a number of small channels which cause the fluid to flow in a spiral pattern before passing through the nozzle, in order to assist in the break up of the particles. The level of restriction required depends, among other things, on the viscosity of the fluid and the size of the holes 544 and nozzle 534.

The pressure in the pressure chamber 518 determines the position of the valve 530, and therefore the higher the pressure in the chamber 518 the closer the valve 530 is to the port 532. After a short period of operation, an equilibrium is established, wherein the pressure in the chamber 518 and therefore the outlet pressure or flow rate of the fluid, can be regulated to a particular level, within approximately +/-10%. The pressure level or flow rate can be varied according to the stiffness or spring rate of the diaphragm 520 and the flow resistance of the fluid from pressure chamber 518 through nozzle 534 and outlet 516. The spring rate of the diaphragm 520 may be set at the time of manufacture by, for example, the size, localised cross section of material, number of the grooves 542 and/or by varying the thickness of diaphragm 520. Once equilibrium is established the position of the valve 530 relative to the port 532 stays substantially constant. This equilibrium state causes the flow of fluid from the nozzle 534 to be substantially constant over a range of pressures in the aerosol container 522.

The nozzle 534 may incorporate a number of apertures of various sizes depending on the flow rate required, the types of operating pressures, and the type of fluid to be dispensed.

In the embodiment shown in figures 5 and 7a-37, the diaphragm 520 is manufactured integrally with the spindle 528. The integral diaphragm and spindle assembly may be made from a plastics material, for example, a plastics material having resilient properties and having good resistance to creep.

It has been discovered that trigger pumps and aerosols are usually only activated in short bursts, and accordingly, the diaphragm 520 is subject to pressure from the pressure chamber 518 for only short periods of time. Therefore, a plastics material is adequate for the purpose of the diaphragm 520.

The spindle 528 is required to have a stiffness sufficient for the valve 530, at the end distal from the diaphragm 520, to be inserted through the port 532, which is of slightly smaller diameter than the valve 530, in order to effect at least a partial seal. Since regulator 510 is not intended to be disassembled, the spindle only has to be sufficiently stiff to withstand pushing the valve 530 through the port 532 once, even if regulator 510 is removed and placed on another container. Further, where the diaphragm and spindle are integral and the nozzle is separate, the flow rate from the regulator can be varied by simply changing nozzles.

The diaphragm and spindle assembly of the present invention may be injection moulded for mass production, either integrally or individually. If the diaphragm and spindle assembly are manufactured separately, the spindle may be attached to the diaphragm by an interference fit, for example, a spindle having a fluted end to be received into an aperture in the diaphragm (not shown). The flutes would allow fluid to travel between the spindle and diaphragm and out of the nozzle.

Alternatively, the spindle 528 and diaphragm 520 are integral as shown in figures 5 and 7a-7d, and the nozzle 534 is inserted into the diaphragm 520 at the aperture 540. Aperture 540 may include a number of number of smaller apertures which allow the fluid to pass therethrough, to the nozzle 534.

In an alternative embodiment shown in figure 8, the spindle 828 may be made integral with the housing 812. A channel 845 connects the inlet 814 to a valve chamber 846. The valve chamber 846 regulates the pressure entering the pressure chamber 818, as the fluid must flow through port 832 in aperture 840. The fluid flow through port 832 is regulated by the movement of the diaphragm 820, relative to the valve 830 on the spindle 828. Increased pressure in the pressure chamber 818 causes the port 832 in the aperture 840, via the diaphragm 820 to move towards the valve 830, thus reducing the flow of fluid entering the pressure chamber 818.

A further embodiment is shown in figure 9, wherein the regulator 910 has the spindle 928 integral with the housing 912. The fluid flows from inlet 914 through a passage 945 into the pressure chamber 918 where it causes the

diaphragm to move relative to the spindle 928. A valve 927 in the diaphragm 918 moves relative to the valve 930 on the spindle, thus controlling the flow of fluid flowing therebetween. In this way, fluid is restricted from flowing into the aperture 940 where it exits through outlet 916.

In the embodiments shown in figures 8 and 9 the use of the aperture in the diaphragm and the spindle attached to the housing allows the diaphragm to be lighter and therefore more responsive to changes in pressure during operation. The most significant change in pressure occurs during the initial opening of the valve in the aerosol container, where pressures rise from atmospheric to several atmospheres very quickly. The attachment of the spindle to the housing reducing the mass of the diaphragm required to move in response to the pressure changes, and therefore the response time is reduced. Further, as the mass of the diaphragm is reduced, but the damping forces in the diaphragm are the same, there is an increase in the overall damping of the diaphragm movement, which reduces hunting.

In all the embodiments shown in figures 5, 7a-7d, 8 and 9, the resilient properties of the diaphragm widen the gap between the ports and the valves as pressure in the pressure chamber decreases. This is achieved using a diaphragm made from a plastics material as the flow of fluid through an aerosol is typically only in short bursts. Therefore a metal spring is not necessary. A plastics material that has good resistance to creep is normally chosen in the construction of the diaphragm, and this is sufficient to prevent creep becoming a factor in the performance of the diaphragm over its short use period. The long periods of inaction typical in aerosol containers enable any initial displacement due to creep to diminish.

A sealing arrangement may be incorporated into the pressure chamber 518, for example, in the embodiment shown in figure 5. This sealing arrangement (not shown) may include any suitable o-ring which seals, for example, with a built up portion on the housing proximate the spindle. In operation, fluid may then flow into the pressure chamber 518, but not through holes 544 and out outlet 516, until a predetermined pressure is achieved in the pressure chamber 518, wherein the diaphragm, and therefore the o-ring, will

move away from the built up potion of the housing. Once the o-ring, or other sealing method, moves away from the built up face of the housing, fluid may flow into holes 544 and out of outlet 516. In this way, fluid flow could be further regulated to within an upper and lower pressure limit and/or operate with a snap open/snap shut functionality.

Referring to the Diaphragm Regulator disclosure, the diaphragms described in the specification and shown in figures 3a-3h may be used with suitable modification for the outlet aperture, in the pressure regulator of the present invention.

Further, a balanced regulator, as shown in the Trigger Pump disclosure, can be used in conjunction with the present invention. In the case of a balanced regulator being used, as, for example, with reference to the regulator shown in figure 5, the nozzle 510 can be removed and a blocked by a wall, and the diaphragm 201(figure 15) could be modified as shown in the present application to accommodate a nozzle. The cover is also removed, thus reducing the number of parts and only requiring one aperture in the housing 512.

While specific arrangements of the diaphragm and aperture have been shown in figures 5, 7a-7d, 8 and 9, there are many different ways in which the aperture and diaphragm of the present invention can be arranged. For example, the aperture may extend all the way through the diaphragm, and the spindle may be attached to the diaphragm by a number of connecting elements;

Further, in the present invention, an aperture is defined to include, among other things:

- a means for allowing fluid to travel from one portion or side of the diaphragm to another portion or side;
- a fluted opening;
- an opening having an insert for directing the flow of fluid;
- a number of openings;
- a mesh covering part of the diaphragm, allowing the flow of fluid therethrough;
- a permeable membrane such that fluid may flow through at least some of the diaphragm;

- a recess.

While the present invention has been discussed in relation to aerosol containers, the regulator could be used in any application where it is desired that a pressure, variable or not, or flow rate of fluid is controlled. Examples of such applications are water pipes or hoses, gas valves, trigger pumps (as discussed in detail in the trigger pump application) etc.

ADJUSTABLE REGULATOR

The adjustable pressure regulating system 1010 as shown in figure 10 includes a supply tank 1012, attached to a pressure pump 1014, by fluid lines 1016 which supply the pump 1014 with fluid. The fluid lines 1016 also include a pressure relief valve 1018, which prevents the pressure in the lines from exceeding a preset maximum. Fluid flows along the fluid line 1016 to a manifold 1017, to which a number of dispensers 1020 are attached. The dispensers each contain a regulator 1022 which regulates the rate of flow of fluid from the dispenser 1020.

The regulator 1122, shown in figure 11, consists of a spring diaphragm 1124 attached to a spindle 1126. The spindle 1126 is in a housing 1128 to form a regulator 1130. At the end of the spindle 1126 is a poppet valve 1132 which prevents fluid from flowing out an outlet 1134 of the dispenser when the pressure drops below a preset minimum. Also attached to each regulator 1122 is a pressure line 1140 which connects the regulator 1122 to a pressure generator 1041. The pressure in the lines 1140 is generated by a pressure source 1041 such as a pump and regulated by an adjustable master pressure regulator 1044. The master pressure regulator 1044 is controlled by a controller 1046, which receives input from a speedometer 1048 as to the speed of the dispenser in relation to the ground.

In use, the speedometer 1048 relays the speed of the vehicle to the controller 1046, which has the amount of fluid needed to be dispersed per unit area pre-programmed. The controller then deduces the rate at which the fluid will need to flow from the dispenser 1020 given the speed of the vehicle. Once the flow rate has been determined, the controller then computes the pressure required in the lines to adjust the flow rate of each dispenser to that required. It

is envisaged that each system will include either an algorithm or a look up table comparing output flow rates to control pressures within a given range. The control pressure will then be adjusted to provide an appropriate pressure behind each diaphragm, thus adjusting the flow rate. This process happens in real time, for example, with the controller sampling the reading from the speedometer at regular intervals to keep the flow rate correct compared to the speed of the vehicle. It should be understood that there is a correlation between the speed of the vehicle and the pressure supplied to control the regulators.

Boom sprayers are often required to spray a range of concentrates at different pre-determined dilution ratios, and at different flow rates depending on the environmental conditions. This high order dispensing requirement necessitates the selection and use of one of a range of nozzles for the optimum spray application for the different combinations that may occur.

Currently, a considerable number of boom sprayers are fitted with mechanisms for changing nozzles, such as carousels at each dispensing position that have alternative nozzles located on them. Alternatively, the boom may be rotatable, and have a number of nozzles radially spaced along the length of the boom. The boom or carousels can be rotated to allow each of the nozzles to be selected. The dispenser 1020 may include one or more nozzles.

The different nozzles are likely to require different flow rates for optimum spray application and therefore the use of an adjustable regulator allows for the necessary variation to be accomplished in a quick and economical way.

In one embodiment, shown in figure 13, nozzles 1350 and 1352 are attached to a carousel 1354 which is fitted to the dispenser 1320. This arrangement allows the fluid dispensed to be sprayed over an area at the optimum rate for a particular nozzle. Alternative fluids, requiring different spray rates, can be accommodated quickly by rotating the carousel to allow a more suitable nozzle to be used. The use of an adjustable regulator in such an arrangement allows the nozzles to each operate at their optimum flow rate, thus ensuring that the rate of fluid flow is controlled, but also that the fluid is dispensed from the nozzle in an efficient manner, i.e. not too slow, where insufficient pressure may cause the fluid to trickle from the nozzle instead of

covering a pre-determined area.

In the present invention, the speed of the surface relative to the dispenser could be measured either separately or taken from means already in place on the vehicle. The pressure behind the diaphragm is preferably from a compressed gas, such as air which allows the diaphragm to move and thus regulate pressure. The pressure in the pressure lines may be from a compressible fluid, such as a gas, or an incompressible liquid, such as hydraulic fluid. In the case of the pressure being provided by an incompressible liquid, an interface between the gas and liquid may be required.

An example of an adjustable pressure regulating system that may be used with the present invention, for example, when mounted onto a tractor, is described below. A compressed air cylinder the same or similar to those used in industry is coupled to an adjustable pressure regulator as commonly used with such cylinders. The speed of the tractor can be determined from the speedometer drive cable and the information can be conveyed electrically to the controller. The controller can then look up the required pressure for that particular tractor speed and fluid output requirement in a look up table, and output the result as a voltage. This voltage output from the controller may be used to vary the output pressure of the variable pressure regulator through a motor which controls the output pressure of the adjustable regulator. The amount of air used by the system is relatively small and therefore the system can be a total loss system, wherein the lines have a bleed off valve which continuously bleeds of air to the atmosphere. In this way the pressure regulator can keep the pressure in the line to the required level by constantly supplying air to the lines, and if a lower pressure is required, the regulator stops or decreases the air supply and the pressure in the lines automatically falls, until the pressure is at the desired level whereupon the pressure regulator begins to supply enough air to the lines to maintain the desired pressure level. To increase the pressure levels in the lines, the pressure regulator simply supplies more air. Obviously other control systems will be apparent to the skilled addressee, and there are many different types of control systems that may be employed with the present invention, which is not intended to be limited to a

specific method of control.

Further the present invention is easily adaptable for conveyor belts moving relative to fixed dispensers, wherein the measurement of the speed of the conveyor belt determines the rate at which fluid is dispensed.

The advantages of the present application are as follows:

an adjustable regulator of simple construction, with few parts;

a simple method of adjusting and controlling the flow from a flow regulator; and

a simple apparatus for controlling the rate of fluid dispensed over a surface from a dispenser moving relative to the surface.

TRIGGER PUMP

This aspect of invention will be described below with reference mainly to one embodiment, which is a trigger pump in combination with a balanced fluid regulator and accumulator chamber. Different embodiments of this invention include the combination of:

a trigger pump with a fluid regulator;

a trigger pump with an accumulator chamber;

a trigger pump with a pressurised bottle and a fluid regulator.

Given that the following disclosure describes each of the above noted features, it is considered that in the light of the following description that a skilled person can assemble the various features to form a number of combinations. In particular, a single faced regulator as described in the 2 Part Regulator and Diaphragm Regulator above.

The trigger pump 1401 as shown in Figure 14 and 1601 in Figure 16 is intended to produce either an intermittent or continuous spray of high quality from a nozzle 1402 by sucking fluid (not shown) through a tube 1403 immersed in the fluid. The tube 1403 having its lower end immersed in the fluid extends into a receiving member 1409. The receiving member 1609 is accommodated within a body 1405 in a first chamber 1411. The body 1405 includes four chambers inter-connected by ports. The first chamber 1411 receives the receiving member 1609 and is connected by a port 1408 to a second chamber hereafter referred to as pump chamber 1407. The receiving member 1609 is

adapted to form a check valve seat for a ball valve 1410, this valve arrangement allows flow in only one direction from an internal chamber 1430 of the receiving member 1609 to the first chamber 1411. The first chamber 1411 is also connected to a third chamber 1423 by a port 1424. The third chamber 1423 is connected via a port 1425 to a fourth chamber hereafter referred to as accumulator chamber 1412. The third chamber 1423 serves as housing for a check valve 1426 which in this embodiment is integral with a moulded spring 1427. The check valve 1426 acts against a formed face of the port 1424 to allow flow only in the direction from the first chamber 1411 to the third chamber 1423. Fluid is also free to flow in either direction between the first chamber 1411 and the pump chamber 1407. Fluid is free to flow in either direction between the third chamber 1423 and the accumulator chamber 1412. The check valve 1426 is guided within the third chamber 1423 by vanes 1431 to ensure that it seats correctly against the port 1424 and also to allow fluid to pass around it.

The lever 1404 is pivoted at pivot point 1435 on the body 1405 of the trigger pump and acts against a piston 1406. The piston 1406 is adapted to form two sliding sealing fits in the pump chamber 1407 and the pump chamber 205. The pump chamber 1407 includes a small port 1408 which communicates with the first chamber 1411. A spring 1429 in the pump chamber 1407 is placed between the closed end of the pump chamber 1407 and the piston 1406 so that the piston is biased in a direction tending to maximise the volume of the pump chamber 1407. A conduit 208 from pump chamber 205 allows atmospheric pressure to be pumped back into the bottle or container (as shown in Figure 16) during the same pumping action for pump chamber 1407. Lateral dimples 206 break the second seal on the reverse stroke allowing air into the second chamber. This chamber avoids the container becoming evacuated. Also if the bottle and trigger pump are inverted the second seal stops fluid leaking out.

A piston 202 forms a sliding sealing fit in the accumulator chamber 1412 and is biased by a spring 204 which is supported by a cap 1428 fixed to the accumulator chamber 1412. The spring acts on the piston 202 in a direction tending to reduce the volume of the accumulator chamber 1412. The spring 204 may be pre loaded (i.e. it is assembled with sufficient initial compression) so that

the piston 202 moves to compress the spring only when the pressure in the chamber 1412 is above the regulating pressure of a regulator 1634. In the embodiment shown in Figure 16, the cap 1628 has an aperture 210, which allows any fluid leaking past the piston 202 to return to the bottle.

A nose housing 1632 is fitted to an end of the body 1605. An extension 1633 of the nose housing 1632 is received within the open end of the third chamber 1623. In the embodiment shown in figures 14 and 15, the spring on the check valve 1426 is received within the extension 1433. The nose housing 1532 contains a nozzle 1502 and the regulator 1534 as best seen in Figures 15 and 17. A number of inter-connected chambers house the fluid regulator and nozzle. The nozzle 1502 may be any suitable nozzle, such as those commonly used in aerosol pressure packs, trigger pumps or custom made nozzles.

The regulator 1534 is part of the nose housing 1532, having an inlet from the tubular extension 1533 opening to a chamber 1514 accommodated within the nose housing 1532. The walls of the chamber 1514 are formed with ports 1515 and 1516. The first port 1515 opens to chamber 1536 and chamber 1514. The second port 1516 opens to chamber 1518, and chambers 1536 and 1518 are connected by the port 1519 which provides a relatively unrestricted communication between the chamber 1518 and chamber 1536. The chambers 1518 and 1536 communicate with the outlet 1517 through a port 1537.

A spindle like support element 1520 is received within the housing 1532 such that it is axially slidable through the ports 1515 and 1516. The support element 1520 supports a set of three valve members 1521, 1522 and 1538 which are associated with the first, second and third ports 1515, 1516 and 1537 respectively. The first and second valves are dimensioned such that they are slidably receivable through the respective first and second ports 1515 and 1516 with a very close tolerance therebetween, however, they do not need to sealingly engage with valve members 1521 and 1522. The valve member 1521 and 1522 can be manufactured with a slight interference with ports 1515 and 1516. The interference will allow the support element 1520 to "push fit" home, but not allow the support element to "push out". This approach is used to reduce consequences of manufacturing tolerances.

The end of the support element 1520 adjacent the outlet 1517 supports the third valve member 1538 which is sealingly engageable with a valve seat provided at the third port 1537. In Figure 17, an o-ring sealing arrangement is shown. Below the minimum pressure requirements, the valve member 1738 seals against the valve seat to stop the flow of fluid.

In Figure 14, the other end of the support element 1420 extends into chamber 1418 and is provided with an enlarged disc-like head which is connected to a flexible diaphragm 201. However, any suitable means of attaching the support member 1420 to the diaphragm may be used. In another embodiment shown in Figure 17, the support element and flexible diaphragm can be combined into one part.

The resilient diaphragm 201 is retained in the housing 1732 by a press fit, thread, adhesive, snap tabs or any other suitable means.

In operation, fluid enters the dip tube 1603 at its lower end. If the pump is initially filled with air, air will flow in the same way as other fluids and for the purposes of this description only fluid, in general, will be discussed. The spring 1629 biases the piston 1606 into a rest position which results in the pump chamber 1607 being filled with fluid. The lever 1604 may be squeezed by finger action (fingers not shown) to move it in a direction towards the pump chamber 1607 about its pivot point 1635. The lever 1604 acts on the piston 1606 and reduces the volume of the chamber 1607 and chamber 205, forcing fluid to flow into the chamber 1611 and air to flow into the bottle to compensate for the fluid removed. The ball check valve 1610 prevents fluid flowing back into chamber 1630 and is forced to flow through the port 1624, unseating the check valve 1626 and thus into the third chamber 1623. Fluid will then flow into the inlet 1614 to the regulator and/or through the port 1625 to the accumulator chamber 1612. If the pressure within the third chamber 1623 is above the opening pressure of the regulator then fluid will flow through the regulator at a substantially constant flow rate. Any excess fluid flow through the port 1624 into the third chamber 1623 will travel through the port 1625 to the accumulator chamber 1612, acting against the piston seal 202 to compress the spring 204. If the pressure in the pump chamber 1607 falls below the pressure in the

accumulator chamber 1612, the check valve 1626 closes and flow from the first chamber 1611 to the third chamber 1623 is stopped. If the pressure within the accumulator chamber 1612 is above the regulating pressure of the regulator 1634, fluid will be forced by the spring 204, piston seal 202 through the port 1625, through the third chamber 1623 and then to the inlet 1614 of the regulator 1634. The flow from the accumulator chamber 1612 will continue until the piston 202 reaches its limit of travel. The lever 1604 may then be activated (squeezed) to increase the pump chamber 1607 pressure above the regulating pressure and fluid flow ill continue.

The lever 1604 may be depressed to a position limited by stops on the lever 1604 or by the coil binding of the spring 1629 or by the piston 1606 contacting the closed end of the piston chamber 1607. When finger force is released, the piston and lever are returned to their rest positions by the spring 1629. The increasing volume of the pump chamber 1607 causes a pressure drop in the pump chamber 1607 which is transferred through the port 1608 to the first chamber 1611. The low pressure causes the ball valve to rise off the valve seat on the receiving member 1609. Fluid is then caused to flow up the dip tube 1603, though the open ball valve 1610 into the chamber 1611, through the port 1608 and into the pump chamber 1607. Thus the pump chamber 1607 is full and ready to supply fluid for the next pump stroke. Air is also drawn into chamber 205 past the piston 1606 whose seal is broken by dimples 206.

The accumulator chamber 1612 has a volume sufficient to provide continuous flow to the regulator 1634 while the pump piston 1606 returns to its rest position. In this manner, the flow to the regulator 1634 can be kept continuous with the single action piston pump (consisting of 1606, 1607 and 1629) being pumped at a comfortable rate via the lever 1604. The volume of fluid held by the accumulator 1612 could be several times the volume of fluid contained in the pump chamber 1607 to allow for an extended period of continuous spray.

Figure 19 shows an alternative embodiment of an accumulator chamber 1612, which is an elastic sleeve. Chamber 1912 may surround the third chamber 1923 and fluid may communicate between the chambers through ports

1930. The ends 1914 of the sleeve 1912 are sealingly joined to the third chamber, providing an expanding chamber for the storage of fluid under pressure. It should be understood that the accumulator chamber can take several forms and be placed in several areas of the trigger pump.

When no fluid pressure is applied to the inlet 1514 and the pressure is insufficient to overcome the biasing force provided by the diaphragm 201 the biasing force provided by the diaphragm ensures engagement of the third valve member 1538 with the third port 1537 to close the regulator and prevent any leakage through the nozzle 1502. On the application of sufficient fluid pressure to the inlet 1514 fluid pressure is admitted to the secondary chamber 1518 through both ports 1515 and 1516 and passageway 1519 by free passage through ports 1515 and 1516 and passageway 1519 which in turn exerts a pressure upon the flexible diaphragm 201.

When the applied pressure reaches a predetermined value, the flexible diaphragm 201 deflects and moves the support element 1520 downward so that the valve member 1538 also moves down and opens the port 1537. Fluid then travels through port 1537 resulting in pressure acting on the top face of the valve member 1538, placing additional load on the flexible diaphragm 201 via the support element 1520. This additional load increases the deflection of the diaphragm causing it to move the support element 1520 and valve members 1522, 1521 and 1538 downwards, thus rapidly increasing the opening of the valve member 1538 in relation to the port 1537 and decreasing the opening of the valve members 1521 and 1522 in relation respectively to the ports 1515 and 1516. Fluid is then able to travel through the regulator 1534 to the outlet 1517 and then through (optional) pre-swirl channels 1540 to the nozzle orifice 1541 located centrally in the nozzle 1502. The decreased opening of the ports 1515 and 1516 throttles the fluid flow through them.

The diaphragm 201 is designed to have a pressure versus displacement curve as shown in Figure 18. It can be seen that an initial pressure 18A is required for any displacement to occur. Any increase in pressure above pressure 18A results in a relatively large displacement of the diaphragm. When the valve members 1521 and 1522 are in close proximity to the ports 1515 and

1516 the fluid flow is restricted causing a pressure drop. The closer the engagement of the valve member and ports, the greater the pressure drop. This results in pressure changes in the chamber 1518 which act against the flexible diaphragm 201. For any inlet pressure above pressure 18A, the flexible diaphragm 201 assumes an equilibrium position of displacement which results in an outlet pressure (in chamber 1518 which is transmitted by free passage through the port 1519 to the chamber 1536 and then by free passage though the port 1537 to the outlet 1517) between pressure 18A and pressure 18C. Point 18B on Figure 18 represents an equilibrium position for a certain inlet pressure 18D where the pressure drop through the valves 1521 and 1522 and the respective ports 1515 and 1516 is such that the pressure in chamber 1518 and 1536 is pressure 18B, and the displacement of the support element is displacement 18B. It can be seen that for a wide range of inlet pressure the outlet pressure remains substantially constant. The inlet pressure exerts no net force on the support element 1520 because pressure forces acting on the facing opposed faces of the valve members 1521 and 1522 cancel each other. This follows the principal of operation of a balanced inlet pressure regulator. An example of such a regulator is shown in US patent No. 5035260. Further, regulators such as those disclosed in 2 Part and Diaphragm Regulators in this specification may also be used.

A specific embodiment of the diaphragm 201 operates in the following manner. In order for the diaphragm 201 to operate, it is desirable to have a large range of movement over a relatively small pressure range as described above. In this way, the support member attached to the diaphragm can move a sufficient distance to open and close the valves 1515 and 1516 over a relatively narrow range of pressures. Also, it is desirable that the support member 1520 not open until a minimum pressure has been achieved, as this provides the lower bound of the pressure regulation. To achieve this, it has been found that a diaphragm with a falling spring rate is desirable, ie more force is required to deflect the diaphragm the first unit of distance than is required to deflect the diaphragm the second unit of distance, as shown in figure 18. Examples of this type of diaphragm are described in this specification in the Diaphragm

Regulator: It is preferable that the regulator should be able to control the upper and lower pressure difference across the nozzle of the trigger pump. There are several ways this can be achieved, including such nozzles as described in US 5035260. Alternatively, other more simple regulators can be used to limit the upper pressure allowed through the nozzle, such as a simple restriction in the nozzle making it difficult to pull the trigger at a sufficient rate to generate higher pressures. A lower pressure regulator may also be employed so that fluid cannot flow through the nozzle until a minimum pressure is achieved.

In order for the pressure to be kept within the limits of any regulation for a suitable time, an accumulator may be included in with the trigger pump. An accumulator may include an expandable chamber whereby fluid can be stored under pressure. This will prolong the time that fluid can travel out of the nozzle within the desired pressure range required for the formation of the appropriate sized droplets. One preferred embodiment of the accumulator includes a chamber having a piston attached to a spring, allowing the storage of pressurised fluid. Another embodiment includes a resilient sleeve surrounding a chamber, wherein there are passages for fluid communication between the chamber and the sleeve, and the ends of the sleeve are sealingly attached to the chamber.

Although it is preferable to include the regulator with the trigger pump and the accumulator, in some applications where a simple and inexpensive device is required, the trigger pump and accumulator chamber can be used in combination to achieve an improved result in the uniformity of droplet size formation can be achieved over a trigger pump by itself. Also, using the trigger pump and the regulator will also improve the result of the droplet size uniformity over a trigger pump alone, and both these combinations are included within the scope of this invention

Good results have been achieved with the trigger pump used with the accumulator and the regulator. If a diaphragm having these properties is connected to a spring, then a pre-tensioning force is able to be applied to the diaphragm. Such a pre-tensioning force is shown in figure 18. A valve (not shown) may be included upstream or downstream from the nozzle in order to

prevent the fluid flowing through the nozzle from drying and possibly clogging the nozzle. Such fluids which will clog nozzles are paint or hairspray. Accordingly, the diaphragm will not move until the force from the pressure on the second chamber equals the force from the spring pre-tension, as seen from where the curves 18C and 18D overlap. The diaphragm and spring properties can be combined in the correct proportion such that the pretension force is in the region where there is only a small increase in force required to produce a relatively large change in movement of the diaphragm and accordingly the support member, as shown in figure 3. This allows the support member to open and close over a relatively narrow pressure range, but not open until a desired pressure is attained. It has also been found that by adjusting the pre-tensioning force, the opening pressure can be varied. A spring tension adjusting mechanism may be attached to the diaphragm so that the pressure at which the valve open can be adjusted. The spring and diaphragm may be separate elements as shown in Figures 14 and 15, or combined as shown in Figures 16 and 17.

In practice the valve members 1521 and 1522 and the ports 1515 and 1516 may not be built to match perfectly and thus there will be an inlet pressure above which the valves will not seal perfectly and thus the outlet pressure will rise. By careful control of the accuracy of the respective valve members and ports, this limiting pressure can be kept above the maximum pressure that can be delivered by the piston pump and thus this presents no limitation to the usefulness of the invention. Alternatively a preset valve could be fitted.

In operation the regulator opens when the inlet pressure rises above pressure 18A and remains open until the inlet pressure drops to approximately pressure 18A. The inlet pressure is essentially the greater of either the pump pressure or the accumulator pressure at any given time, whilst the outlet pressure is either zero (no flow) or substantially constant.

The rate at which the lever is pulled determines whether the flow from the nozzle is intermittent, within certain flow rate bounds, or continuous within the predetermined flow rate bounds. It should be understood that for a fixed nozzle, a constant pressure will result in a constant flow rate.

From Figures 20, 20a and 20b, the various outputs can be seen including the outlet pressure of fluid from a trigger pump without a regulator or accumulator. The variation in pressure and intermittent nature of the fluid flow is clearly shown. If the trigger pump is used in conjunction with the regulator, but without the accumulator, the output of the nozzle will be intermittent as shown in figure 20a. If the trigger pump and regulator are used in conjunction with the accumulator, and the rate of pumping the trigger is sufficiently high, then the output will be substantially constant as shown in figure 20b. If the rate of pumping the trigger falls below the critical rate, then the flow from the nozzle will be intermittent, similar to that shown in Figure 20a. In either case, the pressure across the nozzle, and therefore the flow rate of the fluid, is regulated and therefore the particle size is controlled when either a trigger pump with a regulator and/or an accumulator is used.

It should be understood that if a spray nozzle is not used, and the fluid does not form droplets, then the present invention is still useful in restricting the flow rate of product from the trigger pump.

In a further embodiment, a bottle (not shown) which supplies the fluid may be pressurised by the pump mechanism. The bottle, when used as an accumulator chamber, may be used with or without a fluid regulator. In addition, the fluid regulator may be situated down stream from the pump mechanism, as in the above description, or upstream of the bottle, ensuring that air above a certain pressure is injected into the bottle.

AEROSOL

This aspect relates to application of the above disclosure to aerosols and the like. Referring to figure 21, and figures 22, 23 and 24 with appropriate change in reference numerals, the fluid regulator 2111 is intended to be utilised to deliver fluid at a substantially constant pressure to a spray nozzle 2110 from a high pressure fluid source that may vary in its feed pressure. This fluid source may be an aerosol container containing a propellant such as air.

The nozzle regulator 2111 comprises a housing 2112 having an inlet 2113 which opens into a first chamber 2114 accommodated within the housing 2112. The opposed walls of the first chamber 2114 include a first and second

port 2115 and 2116 respectively. The first port 2115 connects one side of the first chamber 2114 to one side of chamber 2118 and to an outlet 2117 provided in the housing 2112 while the second port 2116 connects the other side of the first chamber 2114 to the other side of chamber 2118. Each side of second chamber 2118 communicates through a fluid passageway 2119 which provides a relatively unrestricted communication of fluid ensuring an insignificant pressure difference between each side of the second chamber 2118 and the outlet 2117.

A spindle like support element 2120 is received within the housing 2112 such that it is axially slidable through the ports 2115 and 2116. The support element 2120 supports two valve members 2121 and 2122 which are associated with the first and second ports 2115 and 2116 respectively. The first and second valves 2121 and 2122 are dimensioned such that they are either slidably receivable through the respective first and second ports 2115 and 2116 with a very close tolerance therebetween or have a small interference that when pushed through can not return.

The support element 2120 has flutes 2131 slidably received within the ports 2115 and 2116. The flutes are relieved to minimise flow resistance and to guide the support element 2120.

The end of the support element 2120 adjacent to the port 2116 extends into the second chamber 2118 and is provided with a ball-like head which is connected to a pressure surface such as a resilient diaphragm 201, via a ball and socket joint 202 or similar means of engagement. In another embodiment (not shown) the support element and flexible diaphragm can be combined to be one part.

The resilient diaphragm 201 is retained by a press fit or other suitable means of retaining the diaphragm 201 in the housing 2112 in a substantially sealing arrangement.

The diaphragm 201 has spring like properties, in that it deflects under pressure but returns to its original shape or position after the removal of the fluid pressure. In the embodiment shown in figure 21, the spring like qualities of the diaphragm come from the shape of the diaphragm. Other examples of

diaphragms are shown in figures 3a-3g.

When at an open or rest position the first valve member 2121 is adjacent but clear of the outlet side of port 2115 while the second valve member 2122 is located within the first chamber 2114 and is adjacent to but clear of the other port 2116. This allows fluid to flow from the first chamber 2114 to the outlet 2117 and also to chamber 2118.

When in a closed position the engagement of the valve members 2121 and 2122 with the respective ports 2115 and 2116 is not a sealing engagement, but providing a restriction to the flow of fluid. The flutes 2131 guide the support element 2120 in the ports 2115 and 2116 and the engagement of the flutes 2131 in the ports 2115 and 2116 is also not a sealing engagement.

On the application of sufficient fluid pressure to the inlet 2113 fluid pressure is admitted to the outlet 2117 and secondary chamber 2118 through the two ports 2115 and 2116 respectively. Passageway 2119 connects outlet 2117 to secondary chamber 2118 allowing a flow of fluid which balances the pressure in the chambers.

The pressure on the flexible diaphragm 201 causes it to deflect laterally which also causes the support element 2120 to move from the open or rest position, to a pressure regulating position, such that the valve members 2121 and 2122 are brought into engagement with ports 2115 and 2116 respectively to restrict the flow from the first chamber 2114 to the outlet 2117 and second chamber 2118. The passageway 2119 ensures that there is little pressure differential between each side of the second chamber 2118. The pressure at the outlet side of the first and second ports 2115 and 2116 is throttled by the degree of engagement of the first and second valves 2121 and 2122 with the first and second ports 2115 and 2116. Should there be a rise in the outlet pressure due to excess fluid flow, the degree of engagement increases thereby increasing throttling. Thus outlet pressure is regulated to remain substantially constant irrespective of supply pressure, above a certain minimum pressure and below a certain maximum pressure. Below the said minimum pressure the diaphragm 201 will have a small deflection so that the valve members 2121 and 2122 are not closely engaged with the ports 2115 and 2116 and thus the

pressure is not throttled to a great extent.

In any case, this will only occur when the aerosol container is almost empty, as normally the pressure in the can is substantially higher than the minimum outlet pressure.

Above the said minimum pressure and once flow commences, the first and second valve members 2121 and 2122 are brought into engagement with the ports 2115 and 2116 respectively to reduce the degree of communication of the fluid pressure applied at the inlet 2113 to the second chamber 2118. On the application of maximum fluid pressure to the inlet 2113 both the first and second valve members 2121 and 2122 move to become almost fully engaged with the respective ports 2115 and 2116 which results in almost no fluid flow. Prior to the fluid flow terminating, the pressure in chamber 2118 via passageway 2119 and outlet 2117 is reduced, therefore causing the diaphragm 201 to reduce its deflection thus creating a condition of fluid flow within predetermined limits.

The valve of the first embodiment may be schematically represented as shown in figure 25. For any value of inlet pressure P1 the forces F1 cancel and for any value of outlet pressure P2 the forces F4 cancel. There are essentially no losses between the chamber 2518 and the outlet 2517 and thus P3=P2. The flexible diaphragm 201 has the pressure P2 acting on it over area A2-A3 plus a force F3. It should be noted that in at least one embodiment spring 2528 is represented by the elastic properties of the materials used to manufacture the diaphragm.

$F3-A3 \, . \, P3$

$P3=P2$

Therefore

$F3=A3 \, . \, P2$

Thus the resultant force biasing the support element 2520 to a throttling position is pressure P2 acting over the entire area A2, plus P3 acting over the area A3. The flexible diaphragm 201 has a pressure versus deflection curve as shown in figure 4.

If the supporting element 2520 is in its open or rest position, any inlet pressure P2 is ported through the open valve members 2521 and 2522 and the

ports 2515 and 2516. The pressure then acts in the chamber 2518 against the flexible diaphragm 201 causing it to deflect according to its pressure versus deflection curve as shown in figure 4. The deflection of the flexible diaphragm 201 causes the supporting element 2520 to move and reduce the gap between the valve members 2521 and 2522 and the respective ports 2515 and 2516. The reduced gap between the valve members 2521 and 2522 and the respective ports 2515 and 2516 causes a restriction to flow which creates a pressure drop through the ports 2515 and 2516 so that the pressure P2 in the chamber 2518 is lower than the inlet pressure P1. The size of the ports 2515 and 2516 and the stiffness of the flexible diaphragm 201 (which gives the pressure versus deflection curve shown in figure 4) is arranged so that for any inlet pressure P1 greater than the minimum regulating pressure (point A on FIG. 4) the outlet pressure P2 is throttled so that it remains substantially constant (between points A and B on FIG. 4).

The balance position for the support element 2520 is one at which the pressure in the second chamber 2518 is held at a level which the force Fs applied by the spring is balanced . If the pressure P2 in the second chamber 2518 continues to increase, the support element is moved to bring the first and second valve members 2521 and 2522 into closer engagement with the first and second ports 2515 and 2516 respectively, to further throttle the flow between the inlet chamber 14 and the second chamber 2518 so as to reduce P2 with respect to P1.

In order for the diaphragm 201 to operate, it is desirable to have a large range of movement over a relatively small pressure range. In this way, the support member 2520 attached to the diaphragm can move a sufficient distance to open and close the valves 2515 and 2516 over a relatively narrow range of pressures compared to the range of pressures in the first chamber 2514. To achieve this, it has been found that a diaphragm having a falling spring rate is desirable, ie more force is required to deflect the diaphragm the first unit of distance than is required to deflect the diaphragm the second unit of distance, as shown in Figure 4. The desired diaphragm and spring properties can be combined in the correct proportion such that only a small increase in force is

required to produce a relatively large change in movement of the diaphragm and accordingly the support member.

The balance between the deflection and the spring rate of the diaphragm is determined by the properties of the materials used and the size and shape of the diaphragm.

If the inlet pressure P1 is low (i.e. nearly equal to P2) the extent of throttling by the first and second valve member 2515 and 2516 is low and resistance to flow is low. If the inlet pressure P1 is much greater than the pressure P2 in the second chamber 2518 the throttling by the first and second valve members 2515 and 2516 is greater. The minimal extent of movement of the spindle required to vary the extent of throttling to control the pressure P2 in the second chamber results in only a slight difference on the force Fs applied by spring 2528 or the diaphragm 201. This implies a higher regulation of pressure for instances of a high inlet pressure than for low inlet pressures however in practice the difference in the degree of regulation has been found to be negligible.

The embodiments shown in figures 23 and 24 relate to the use of a pressure regulating valve inside an aerosol container. The advantage of this approach is that the container cannot be refilled easily. Refilling of the container is dangerous for the purchaser, as the contents may not be those marked on the container, the container may be damaged, or the contents may be at a higher pressure than is safe. Also product contamination is of concern.

A regulator 2310 used in these embodiments includes an on-off valve. In normal usage, the regulator 2310 works in a similar way as the regulator of previous embodiments. The regulator 2310 is incorporated into the container and is therefore resistant to tampering.

On refilling, the pressure in the regulator 2410, specifically in a chamber 2418, increases. This causes valves 2421 and 2422 to move towards ports 2415 and 2416 respectively thus stopping or severely restricting the flow of fluid into the container and therefore preventing the container from being refilled.

This is a surprising result as the properties of fluid flow back into the regulator 2410 were not known, and it is not obvious to use the regulator in an

inbuilt fashion for this purpose.

The diaphragm used in this embodiment incorporates a separate spring 2428 and diaphragm 2429. The spring 2428 and diaphragm 2429, when separate can be matched to exhibit the same properties as diaphragm 201 of the other embodiment. It should be recognised that the embodiments of the spring and diaphragm or diaphragm alone achieve the same result and therefore can be readily swapped.

As shown in figures 3a-3g, there are several different embodiments of the diaphragm. Diaphragm 330 is in the shape of a flat disc, with cylindrical sides 340 to provide a means of aligning the diaphragm during assembly, and to provide a seal against fluid leaking past the sides 340. The support member 320 is shown integral with the diaphragm 330, as are the other embodiments shown in figures 3a-3g, however, the diaphragm and support member may be separate and any suitable attachment means may be employed.

Diaphragm 331, in figure 3b, includes an outer annular portion 341 and an inner annular portion 341a which are thinner than the rest of the disc, thus reducing the stiffness of the diaphragm, according to the desired pressure and displacement relationship required. Many such annular portions can be included to achieve a sufficiency in stiffness, however, a particular advantage has been discovered using at least two annular portions in that the thinner areas act as hinges allowing the support member 320 to move laterally. The hinges coalesce the stress in the annular portions 341, 341a. The annular portion may be on either side of the disc.

Diaphragm 332 is shown with the disc portion 342 including corrugations to enhance the movement of the disc in response to changes in pressure. The corrugations allow the disc to extend and therefore, provide the support member 20 with more lateral movement, while not stressing the material of the disc sufficiently to cause permanent plastic deformation. Annular portions as shown in Figure 6b may be included with the corrugations, to further increase the range of movement of the support member 320.

Diaphragm 333 includes a number of radial depressions 343, which reduce the stiffness of the disc to a desired level.

A further alternative is that the diaphragm may employ bellville spring design principles as shown in figure 3e. In this embodiment, the diaphragm is biased towards a concave position, shown in figure 3e. The concavity of the diaphragm depends on the pressure on the diaphragm 334. When there is no net pressure from the fluid acting on the diaphragm, ie no fluid flow, then the diaphragm 334 is more concave. When there is fluid pressure acting on the diaphragm 334, then the pressure causes the diaphragm to move axially and becomes less concave, wherein the spring rate is reduced as shown in figure 4. When the pressure is released, the diaphragm springs back to its original position shown in figure 3e.

In figure 3f, there is shown a diaphragm 335 which includes a number of circular corrugations 344 orientated axially to produce a bellows arrangement, which allows increased axial movement whilst maintaining a more constant spring rate. The spindle 320, diaphragm 335 and corrugations 344 may all be made from the same material, such as a plastics material.

In figure 3g, there is shown a diaphragm 336 which includes one or a number of concentric rings or tubes 337 with a flexible attachment 338 therebetween. The flexible attachments 338 act like hinges with low radial stiffness, low bending stiffness and high axial stiffness. The small volume of material in these regions is allowed to operate at high stress. In doing so, they attract only a small proportion of the total strain energy applied to the diaphragm. The much larger volume concentric rings operate at a lower stress to reduce the effects of creep because due to their relative bulk, they absorb the majority of the total strain energy.

In Figure 26 the relationship between the force on a Bellville spring versus the deflection is shown. It can be seen that the force required to deflect the spring rises until a critical maximum point is reached. Either side of this critical maximum force, the spring rate reduces which results in a large movement in the diaphragm for a relatively small pressure change. This reduction in spring rate is desirable in that it provides a narrow range of pressures in which the outlet pressure may be regulated.

Additionally, there may be a shut off valve upstream from the outlet

nozzle, in order to reduce the drying of any product left in the chambers after the flow has ceased. Typically, when residues of fluids such as paint and hairspray remain inside spray nozzles, they can dry and clog the nozzle. The shut off valve can be incorporated into the regulator between the chambers and the outlet in order to stop any drying of product.

Further, a check valve may be situated upstream from the inlet so that if the regulator is inverted, the valve will block the flow of propellant through the regulator. This ensures that propellant is not lost from the aerosol container by expelling propellant without expelling the product, which, typically being a liquid in the can, would not enter the dip tube while the container was inverted.

It should be appreciated that the scope of the invention(s) disclosed need not be limited to the particular scope of the embodiment described above.

From the above descriptions, the diaphragms are designed symmetrically so that the support member 320 moves linearly when the diaphragm deflects under fluid pressure. The various axially symmetrical weakened portions in the diaphragm are designed to offer structural support to the support member 320 but retain enough elasticity to deflect enough when subjected to the fluid pressure during operation of the regulator. The surprising aspect of the diaphragm arrangements disclosed herein is that a plastic can be used as a valve and retain its elasticity properties over the expected use cycle of the regulator. This is due to the use characteristics of a regulator with an aerosol container, i.e. infrequent short bursts that do not allow creep or permanent plastic deformation to become significant to the operation of the regulator. It has been found that using a plastic with a good memory of its original position, such as acetal, is sufficient.

It should be appreciated that the scope of the present invention need not be limited to the particular scope of the embodiments described above and certain modifications can be made whilst still maintaining the scope of the inventions disclosed above.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A fluid regulator including a spring diaphragm.

2. The fluid regulator as claimed in claim 1 having an inlet chamber and an outlet chamber, wherein at least one valve is attached to a spindle and situated adjacent at least one corresponding port in the inlet chamber to restrict flow to the outlet chamber such that there is minimal net force on the valves from the inlet pressure of the fluid.

3. The fluid regulator of claim 2 wherein the diaphragm controls the clearance between the valves and ports by moving in response to changes in the outlet pressure and thereby regulating the flow of fluid from the inlet to the outlet chamber.

4. The fluid regulator according to any of the preceding claims wherein one side of the spring diaphragm is open to the atmosphere and the other side is exposed to the outlet pressure of the regulator.

5. The fluid regulator as claimed in any of claims 1 to 4 wherein the spring diaphragm is sealingly attached to a housing of the regulator.

6. A fluid regulator having a spring diaphragm, support member and valve of unitary construction.

7. A fluid regulator having a diaphragm which is not subject to a biasing force when no fluid is flowing.

8. The diaphragm as claimed in any one of claims 1 to 7, wherein the diaphragm is constructed from the same material as the valves and spindle.

9. The diaphragm as claimed in any one of claims 1 to 8, wherein the diaphragm is made from a plastics material.

10. A spring diaphragm in the form of a membrane.

11. The spring diaphragm of claim 10, where the membrane is in the form of a plate.

12. The diaphragm as claimed in claim 10 or 11, having at least one weakened portion.

13. The diaphragm as claimed in any one of claims 1 to 12, wherein the weakened portion includes at least one annular groove or area of reduced thickness.

14. The diaphragm as claimed in any one of claims 1 to 13, having a number of radial grooves or areas of reduced thickness.

15. The diaphragm as claimed in any one of claims 1 to 14 having a rippled surface.

16. A diaphragm as claimed in any one of claims 1 to 15, wherein a collar for attaching the diaphragm to the regulator is spaced laterally from the diaphragm.

17. A fluid and/or pressure regulator including a diaphragm having an outlet aperture therein.

18. A fluid and/or pressure regulator having a diaphragm, an outlet and a pressure chamber, wherein the diaphragm is situated on the outlet side of the pressure chamber.

19. The regulator of claim 18, wherein the outlet is within the diaphragm.

20. The regulator as claimed in claim 18 or 19, wherein the diaphragm is situated downstream from a valve.

21. The regulator of claim 20, wherein the diaphragm is operatively coupled to the valve which restricts fluid flow through the inlet of the pressure chamber.

22. A fluid and/or pressure regulator including a diaphragm having an aperture therein through which fluid flows.

23. The regulator of claim 22, wherein a portion of the diaphragm forms part of a pressure chamber, and a portion of a housing with a valve forms another part of the pressure chamber, and the aperture moves relative to the valve to regulate the flow of fluid into the pressure chamber.

24. A regulator comprising a spring diaphragm, a valve and a housing.

25. The regulator of claim 24, wherein the spring diaphragm contains an aperture therein.

26. The regulator of claim 24, having a pressure chamber formed at least in part by the spring diaphragm, and the housing having the valve attached thereto, wherein changes in pressure in the pressure chamber cause the aperture in the spring diaphragm to move relative to the valve, thus regulating the flow of fluid into the pressure chamber.

27. The regulator of claim 24, wherein either of the housing or the diaphragm has an aperture, and the other of the housing or diaphragm has the valve.

28. The regulator of claims 23, 26 and 27, wherein fluid flows into the pressure chamber through an inlet of the housing and out of the pressure chamber through an outlet in the diaphragm.

29. The regulator of claim 28, wherein the spring diaphragm and outlet cooperate to provide regulation of fluid flow into and/or pressure inside of the pressure chamber.

30. A three part fluid regulator, comprising a spring diaphragm, a valve and a housing (actuator).

31. A regulator as claimed in claim 30, wherein an outlet aperture is provided in one of the housing, diaphragm or valve.

32. A two part fluid regulator comprising a spring diaphragm including an outlet aperture and a port portion of valve means, and a housing including a body member defining a portion of an actuator and an integral spindle.

33. A two part fluid regulator comprising a spring diaphragm including an outlet aperture and an integral spindle, and a housing including a body member defining a portion of an actuator and a port portion of valve means.

34. The regulator of any one of claims 17 to 33, wherein the outlet aperture functions as a nozzle and/or contains a nozzle.

35. The regulator of any one of claims 17 to 34, wherein the diaphragm is made from a plastics material.

36. A pressure and/or fluid regulator as shown in figures 5, 7a-7d, 8 or 9.

37. The regulator of any one of claims 17 to 36, wherein the spindle and diaphragm are integral.

38. The regulator of any one of claims 17 to 37, wherein the spindle is integral with the housing.

39. The regulator of any of claims 17 to 38, wherein the diaphragm is partially uncovered.

40. In combination, a spring diaphragm having an outlet therein and an aerosol or trigger pump as herein disclosed.

41. A combination as claimed in claim 40, wherein the diaphragm serves to provide flow and/or pressure regulation.

42. A method of assembling an actuator, including connecting a spring diaphragm and a housing (actuator) together.

43. An adjustable fluid regulator including a spring diaphragm for controlling the output of the fluid from the regulator, wherein one side of the diaphragm is exposed to the fluid and the other side of the diaphragm is exposed to a source of pressure.

44. The adjustable fluid regulator of claim 43, including a balanced regulator.

45. The adjustable fluid regulator of claim 43 or 44, wherein the source of pressure is adjustable.

46. The adjustable fluid regulator of any one of claims 43 to 45, wherein the source of pressure is connected to at least one adjustable fluid regulator.

47. The adjustable fluid regulator of any one of claims 43 to 46, which are connected to a controllable source of variable pressure by conduits.

48. The adjustable fluid regulator of any one of claims 43 to 47, wherein the output of fluid from the regulator flows through a nozzle which is mounted on the regulator by a carousel.

49. The adjustable fluid regulator of claim 48, wherein there are a number of nozzles mounted to the carousel.

50. An apparatus for controlling and adjusting the rate of fluid flow from one or more fluid dispensers moving over a surface, including:

a fluid regulator;

a sensor for detecting the speed of the dispensers over the surface;

an adjustable pressure generator; and

a control means,

wherein the regulator includes a diaphragm which adjusts the flow rate of fluid from the dispensers, and the sensor detects the speed of the dispensers over the surface and adjusts the pressure on one side of the diaphragm to control the rate of fluid flowing from the dispensers, dependant on that speed.

51. The apparatus of claim 50, which also includes a number of nozzles mounted to the dispenser by a mechanism that allows different nozzle types to be selected.

52. A method of adjusting the rate of fluid flow from one or more dispensers having a diaphragm flow regulator wherein the speed of the dispenser over the surface varies, by:

measuring the speed of the dispenser relative to the surface; and

varying the pressure on one side of the diaphragm to control the output of fluid from the dispenser in response to the speed of the dispenser.

53. The method of claim 52, wherein there is more than one dispenser moving over the surface.

54. The adjustable fluid regulator of any one of claims 43 to 53, wherein each dispenser has a regulator.

55. A fluid regulator comprising a housing having an inlet and an outlet, said housing providing a first chamber open to the inlet, the first chamber being provided with a pair of substantially opposed ports which open to a second chamber, the second chamber having a third port opening to the outlet, an axial support element movable through the pair of ports and received within the first and second chambers, a support element supporting a pair of valve members wherein a valve member is associated with each of the pair of ports, the support element being movable within the first and second chambers to vary the extent of engagement of the pair of valve members with the pair of ports, said support element further supporting a third valve member at one end which is associated with the third port, said support element being biased to an end position at which the pair of ports are open, and the third port is closed, said support element further supporting a pressure surface at the other end which is in the second chamber whereby the force exerted by fluid pressure in the second chamber on the support element counteracts the biasing force applied thereto to rapidly move the support element from its end position to a regulating position where the pair of valves are moved proximate their respective ports to vary the degree of opening of the ports in accordance with the fluid pressure applied at the inlet.

56. A fluid regulator as claimed in claim 1 wherein when the support element is at its regulating position the third valve member is spaced clear of the third port such that there is substantially no throttling of the fluid flow through the third port.

57. A fluid regulator as claimed in claim 55, wherein the biasing force is adapted to be varied.

58. A trigger pump including an accumulator to substantially even out the fluid pressure at the outlet.

59. A trigger pump including an accumulator and a fluid regulator to substantially even out the fluid pressure at the outlet.

60. A trigger pump and regulator in combination.

61. A trigger pump and sleeve accumulator in combination.

62. A trigger pump which is adapted to pressurise a container coupled thereto, and which includes a regulator.

63. A trigger pump as claimed in claim 62, wherein the regulator is provided proximate the dispensing nozzle.

64. A trigger pump as claimed in claim 62, wherein the regulator is provided to control and/or regulate pressure and/or flow rate of fluid delivered to and/or from the container.

65. A fluid regulator as claimed at claim 55, wherein the support element and flexible diaphragm can be combined to be one part.

66. A fluid regulator as claimed in claim 55, wherein the third valve member is omitted and the function of the third valve is done using the rear face of the valve such that there is substantially no throttling of the fluid flow through the third port.

67. A fluid regulator as claimed in claim 55, wherein an additional spring is inserted internally or externally which in combination with the existing spring diaphragm provides the biasing force and regulating force.

68. The fluid regulator as claimed in any one of claims 55 to 67, including a bypass gallery which avoids a condition of no fluid flow.

69. Fluted bearing guides which support a movable element axially whilst allowing fluid flow between galleries.

70. A trigger pump including a regulator having a spring diaphragm therein.

71. A regulator as claimed in any one of claims 55 to 68, having a spring diaphragm therein.

72. A method of fluid regulation for a trigger pump including the steps of:

passing fluid from one location to another location;

regulating or controlling the flow of the passing fluid by passing the fluid through a fluid regulator.

73. A method of fluid regulation for a trigger pump including the steps of:

drawing fluid through a first pump chamber and one way valve into a second pump chamber;

pumping fluid from the second chamber into a pressure chamber having a one way valve, wherein the pressure chamber stores the fluid under pressure;

when the stored fluid attains a predetermined pressure, expelling the fluid from the pressure chamber through a regulator, wherein the regulator regulates the fluid flow from the trigger pump.

74. A method of fluid regulation for a trigger pump including the steps of:

drawing fluid through a first pump chamber and one way valve into a second pump chamber;

pumping the fluid form the second chamber into a pressure chamber through a one way valve, wherein pressurised fluid is stored in the chamber, and expelled from the trigger pump.

75. A fluid regulator comprising a housing having an inlet and an outlet, said housing providing a first chamber open to the inlet, the first chamber being provided with a pair of substantially opposed ports which open to a second

chamber, the second chamber having a third port opening to the outlet, an axial support element movable through the pair of ports and received within the first and second chambers, the support element supporting a pair of valve members wherein a valve member is associated with each of the pair of ports, the support element being movable within the first and second chambers to vary the extent of engagement of the pair of valve members with the pair of ports, said support element further supporting a pressure surface at the other end which is in the second chamber, whereby the force exerted by fluid pressure in the second chamber on the support element counteracts the open or rest force applied thereto to move the support element from its rest position to a regulating position where the pair of valves are moved proximate their respective ports to vary the degree of opening of the ports in accordance with the fluid pressure applied at the inlet.

76. A fluid regulator as claimed in claim 75, wherein the support element and pressure surface can be combined to be one part.

77. A fluid regulator as claimed in claim 75 or 76, wherein the support element is supported by fluted bearing guides which allow fluid flow between the chambers.

78. A fluid regulator as claimed in any of claims 75 to 78, wherein the chambers are connected by a passage allowing the communication of fluid.

79. An aerosol including a compressed gaseous propellent, in which there is provided a balanced regulator to substantially regulate product dispersal flow.

80. An aerosol including a compressed gaseous propellent, in which there is provided a regulator as claimed in any one of claims 1 to 7, 18 to 39, 43 to 49, 54 to 57, 65 to 68 or 71 to substantially regulate product dispersal flow.

81. The aerosol of claim 79 or 80, wherein the regulator is provided in an

actuator.

82. An aerosol as claimed in claim 81, wherein the balanced regulator does not include a shut off valve.

83. An aerosol which includes a regulator (of any type) inside the aerosol vessel.

84. An aerosol as claimed in claim 83, wherein the regulator is a one way valve.

85. A regulator as claimed in any one of claims 75 to 78, wherein one face of the regulator valve acts as a shut off valve.

86. A regulator as claimed in claim 85, wherein the face, in use when regulating, is spaced from the outlet such that there is substantially no throttling of fluid flow through the outlet.

87. An aerosol including a regulator as claimed in any one of claims 85 or 86.

88. An aerosol having a regulator to control the flow of contents from the aerosol, and in which the propellant is a compressed, liquefied and/or pressurised fluid.

89. The aerosol of claim 88, wherein the propellant is air.

90. A regulator as herein disclosed.

91. A diaphragm as herein disclosed.

Fig 1.

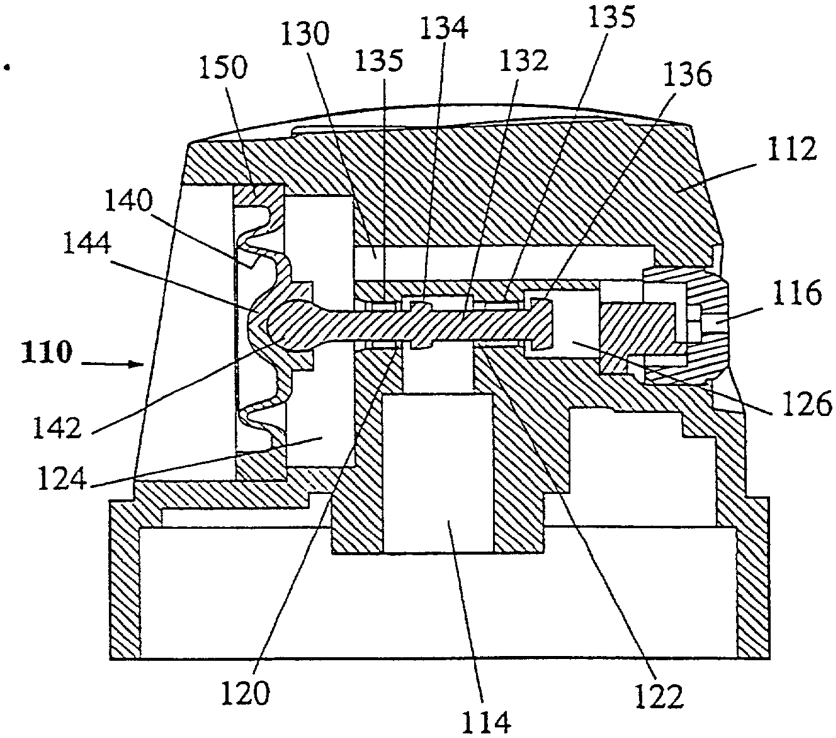
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Fig 2.

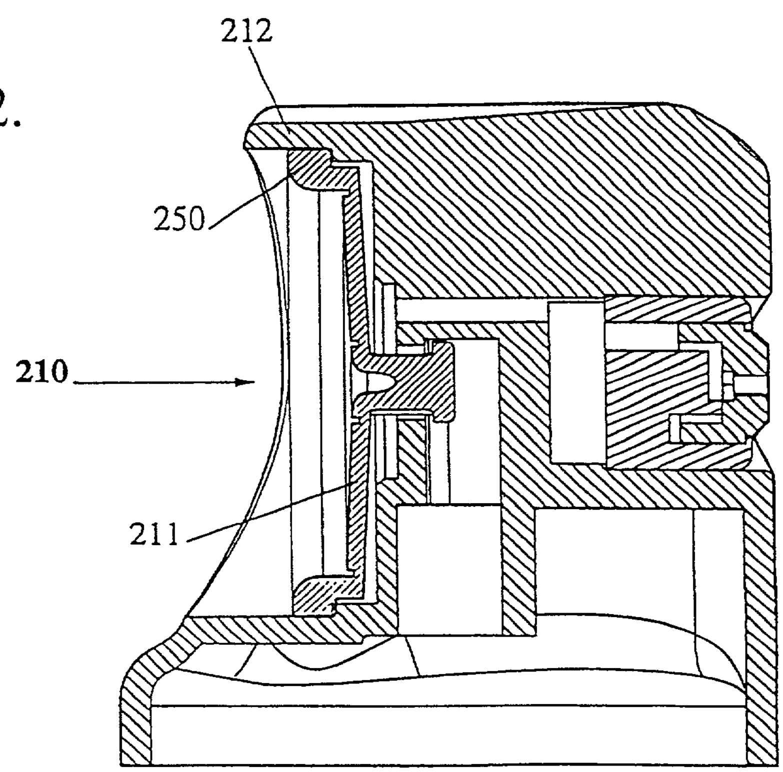
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Fig 3a.

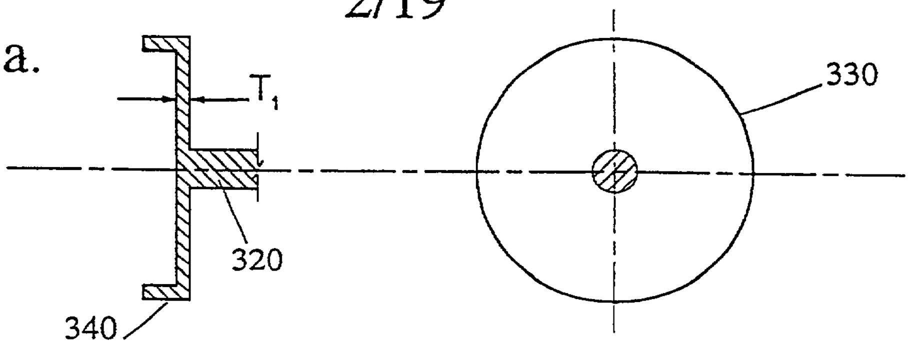


Fig 3b.

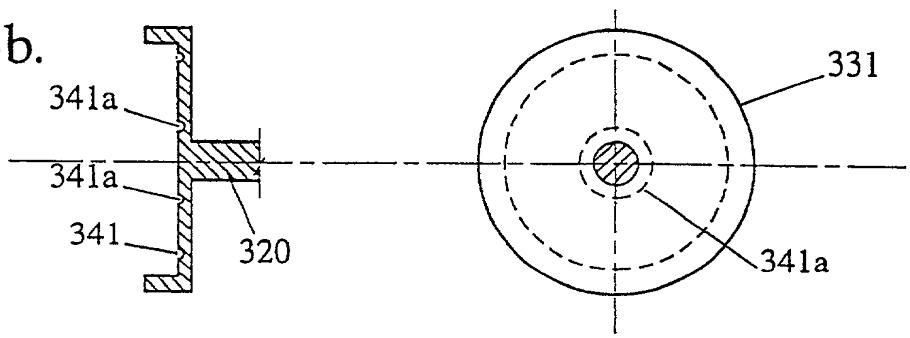


Fig 3c.

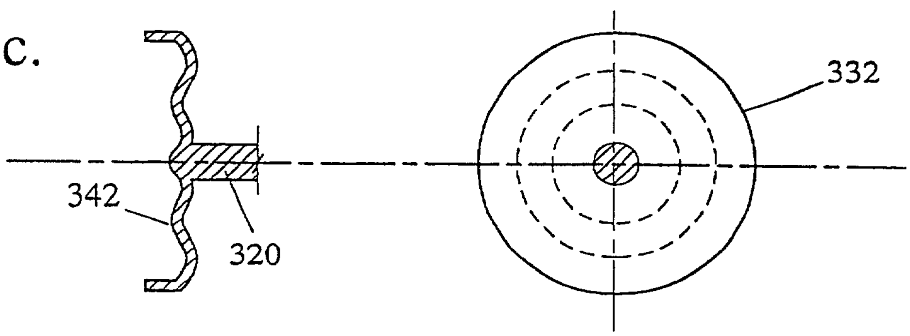


Fig 3d.

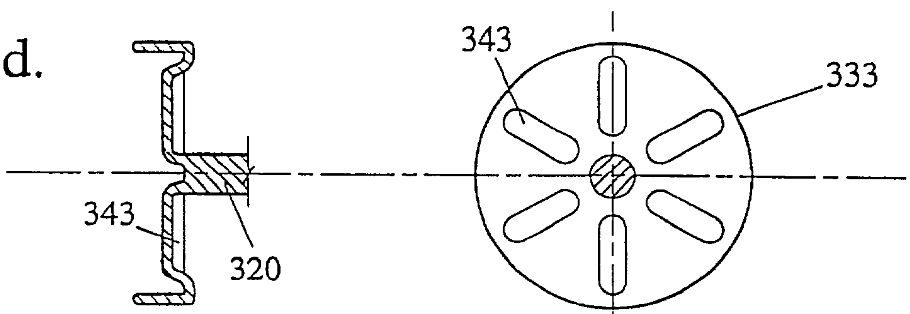


Fig 3e.

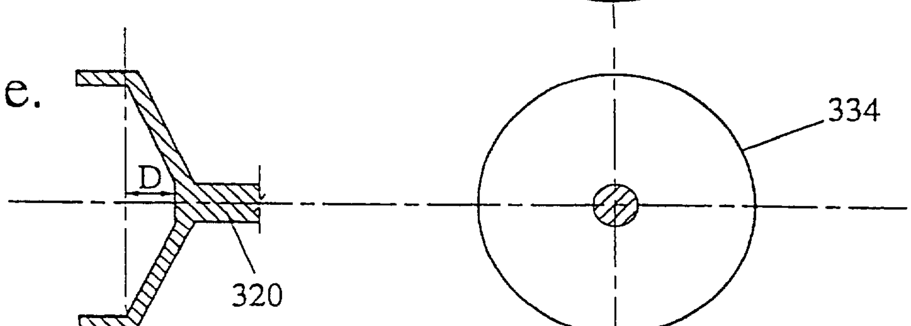


Fig 3f.

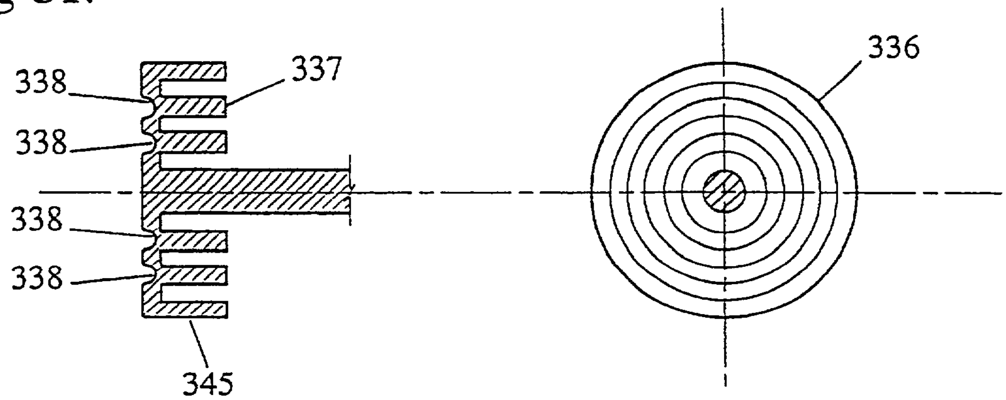
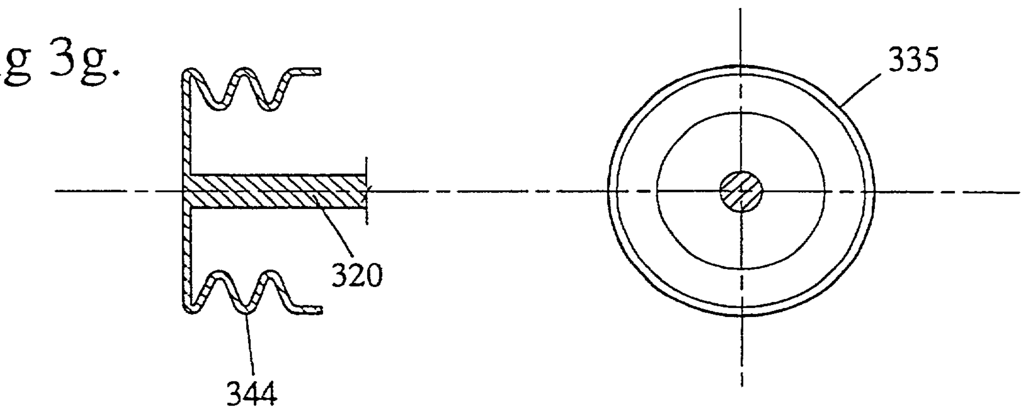


Fig 3g.



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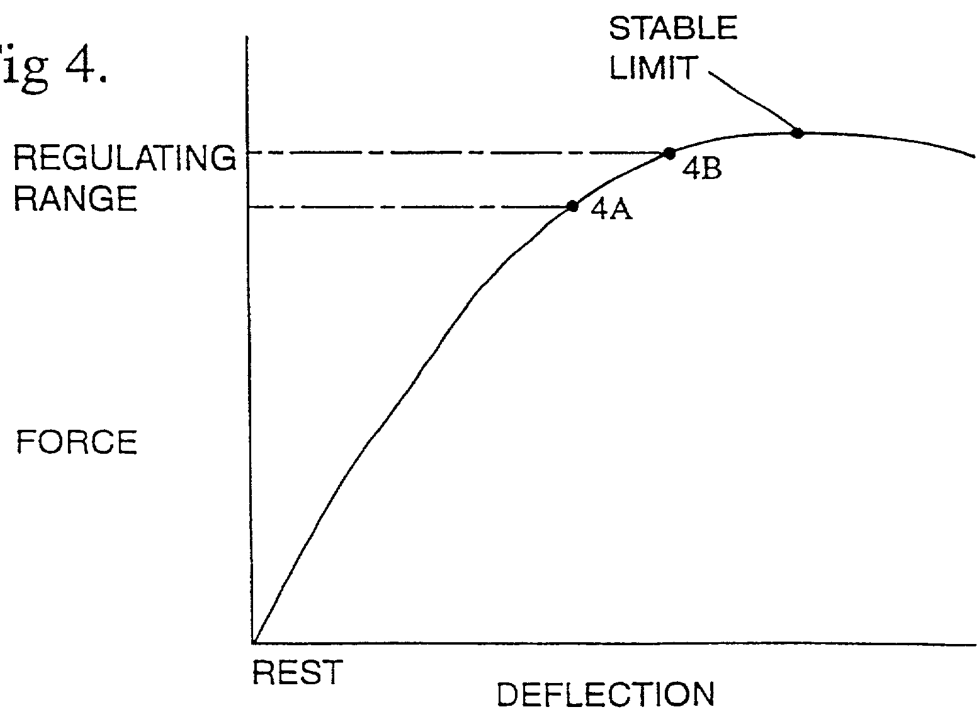

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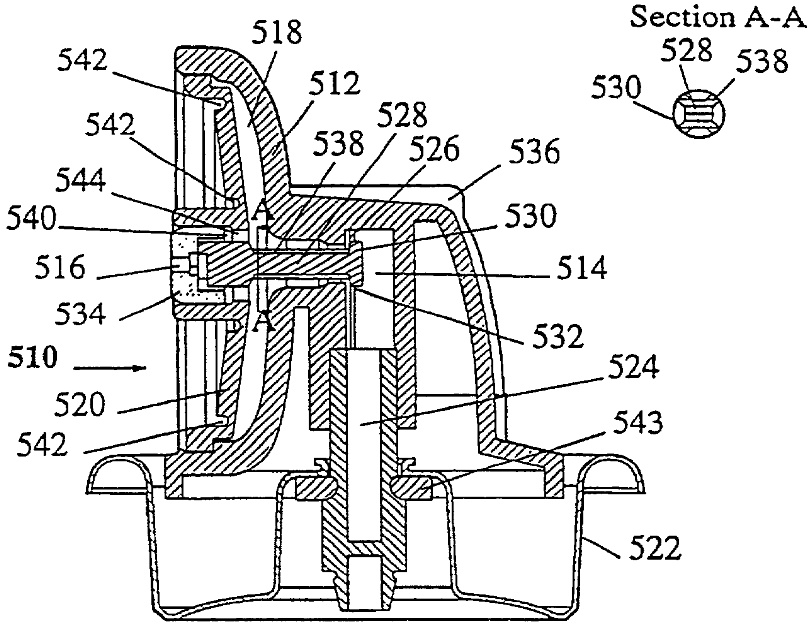

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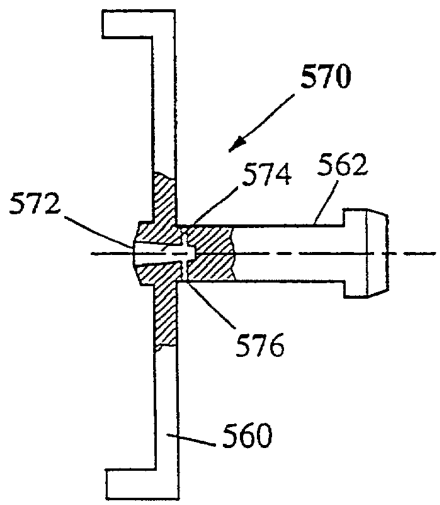


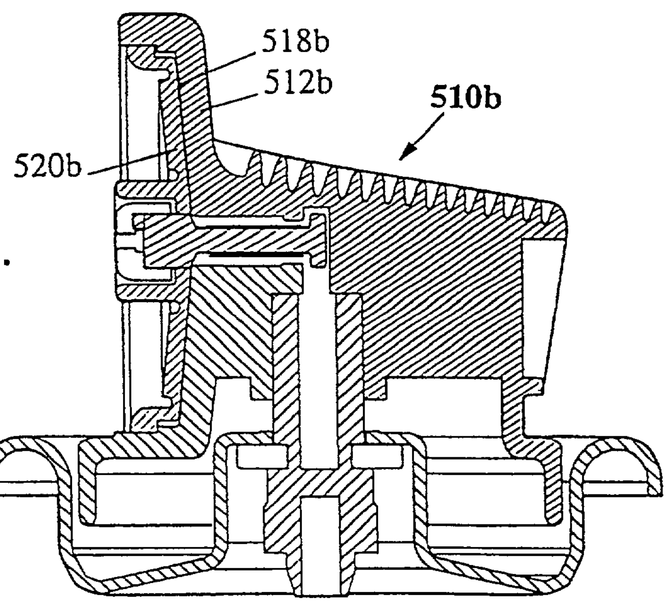


Fig 5b.

Fig 6a.

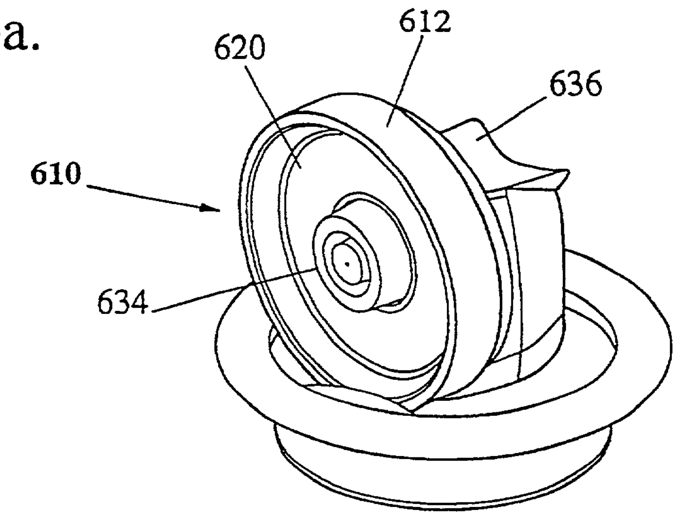


Fig 6b.

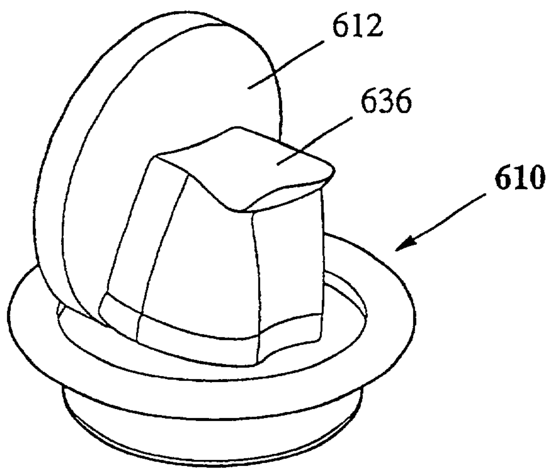


Fig 6c.

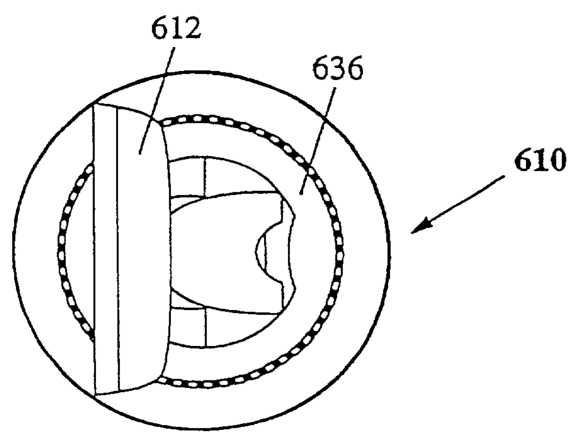


Fig 7a.
Section B-B

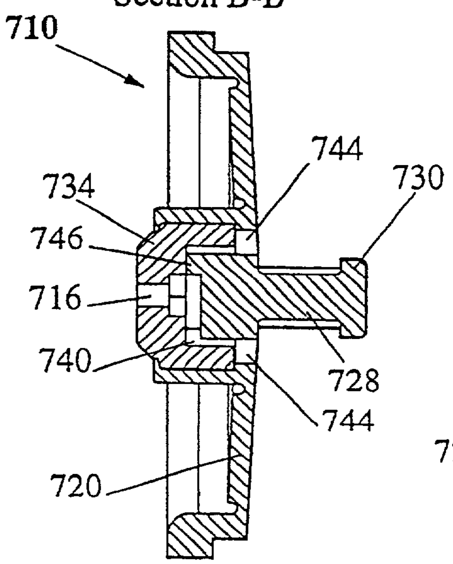


Fig 7b.

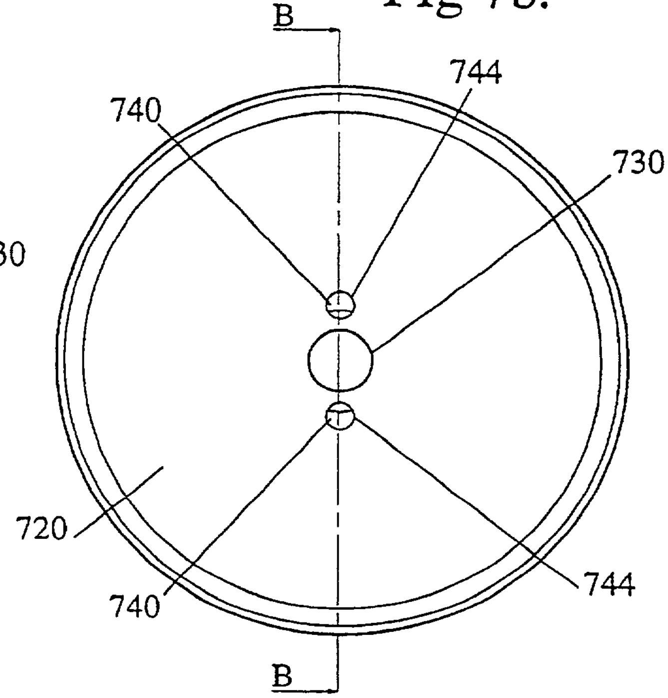


Fig 7c.

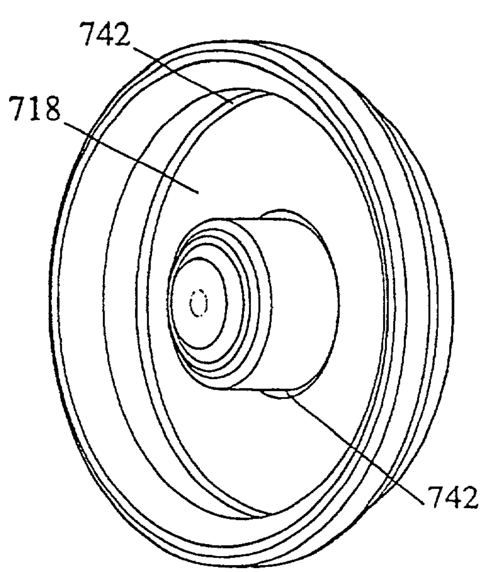
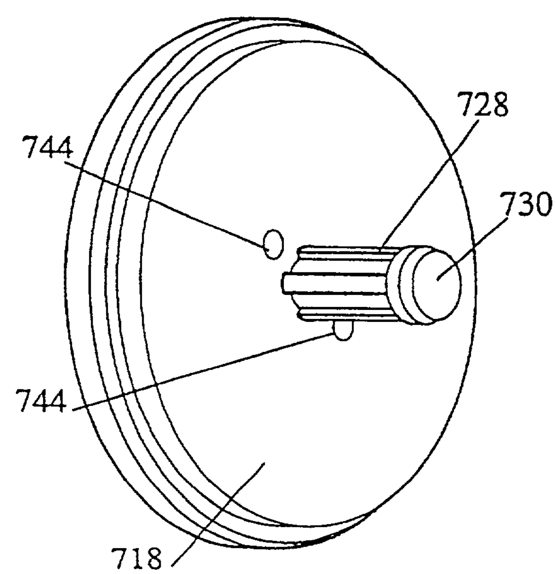


Fig 7d.



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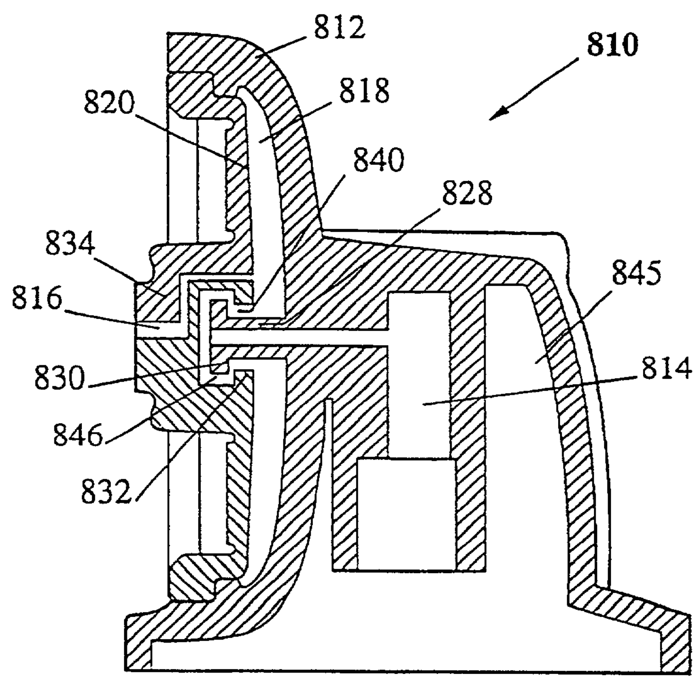
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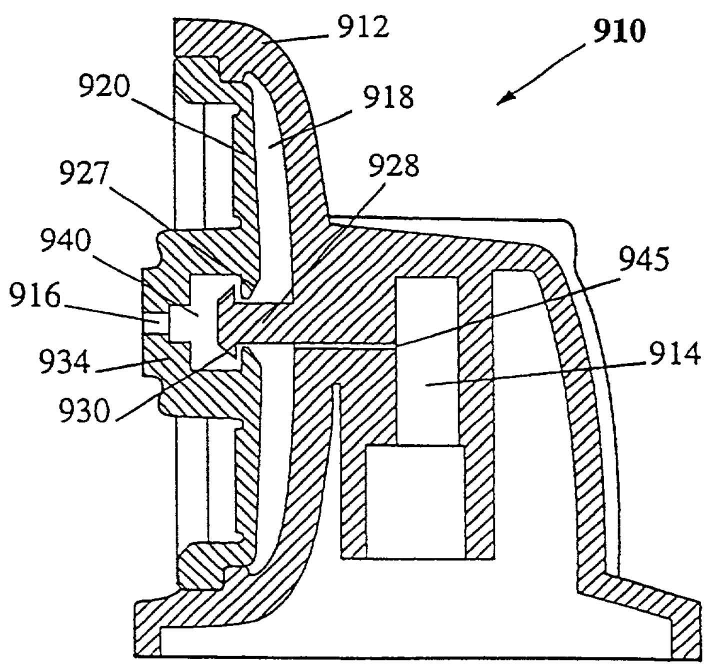
Fig 9.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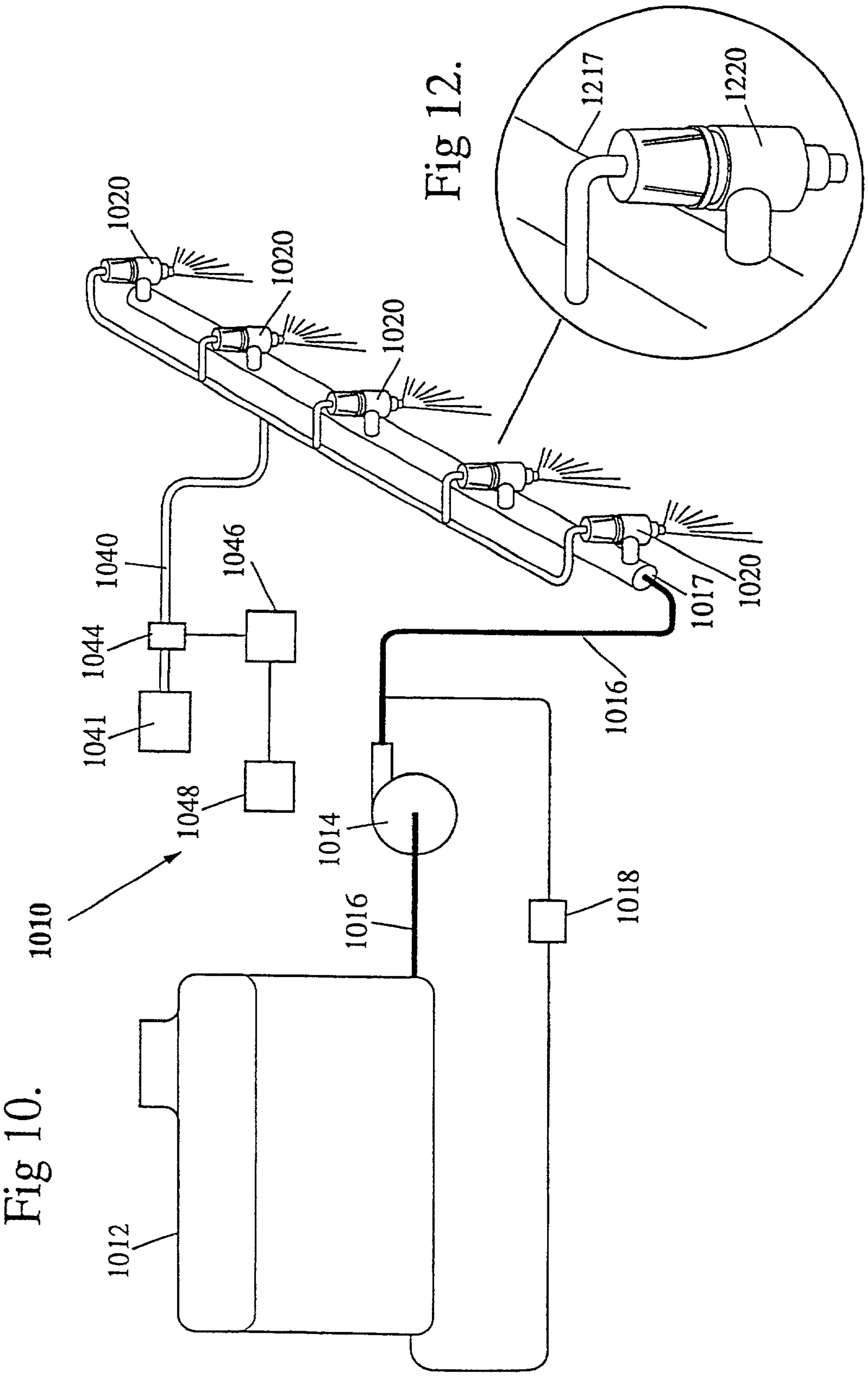
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Fig 10.

Fig 12.

Fig 11.

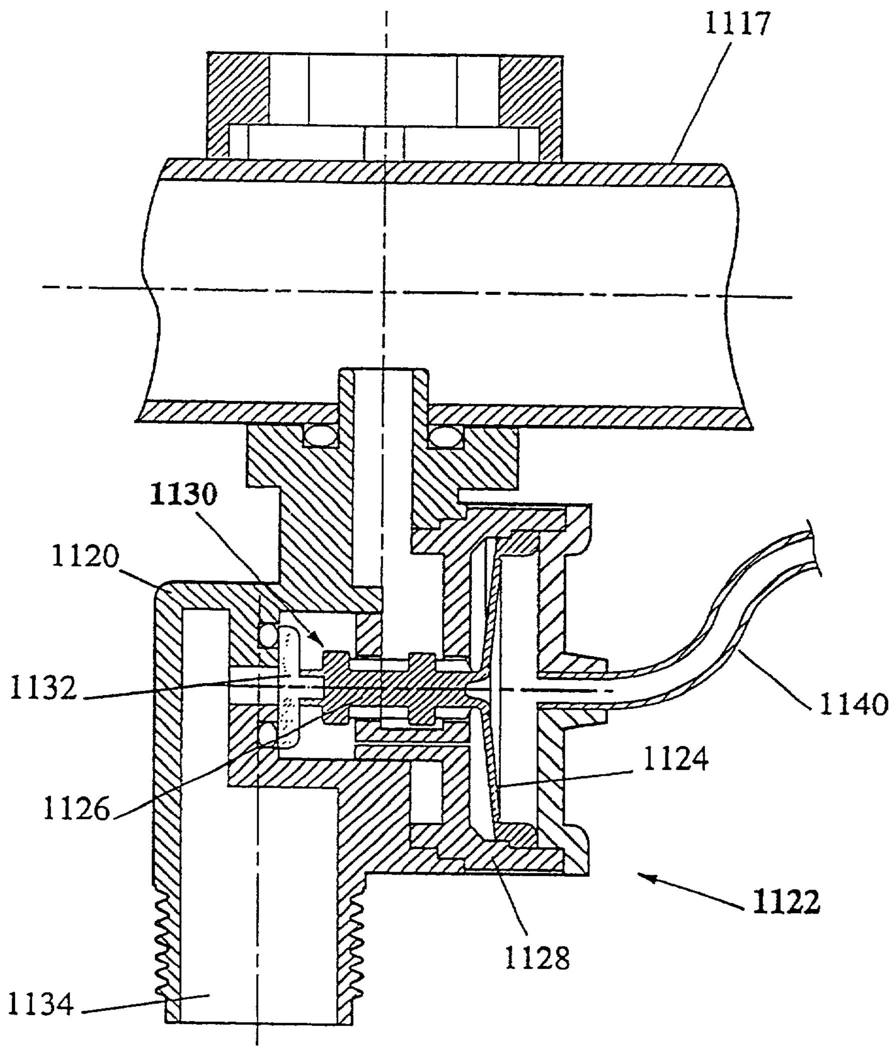


Fig 13.

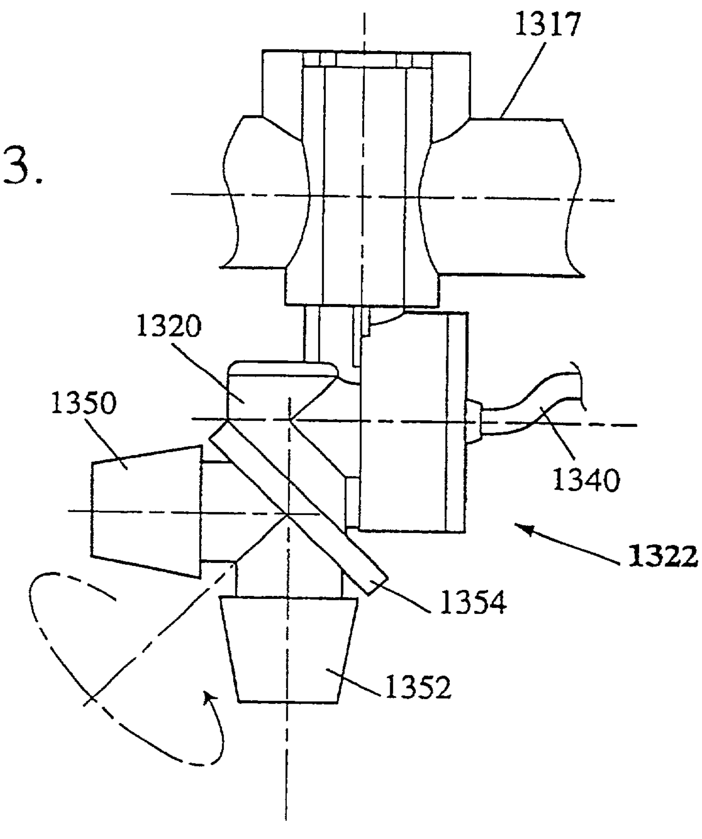
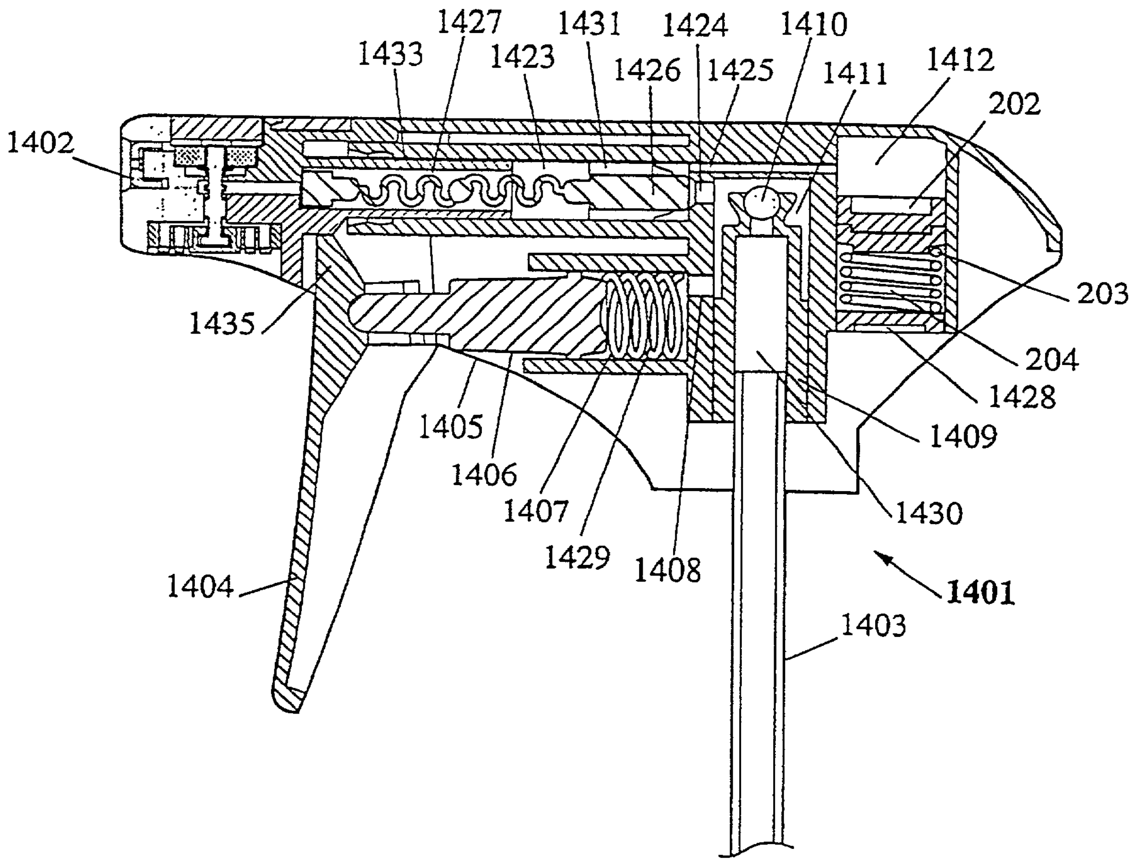


Fig 14.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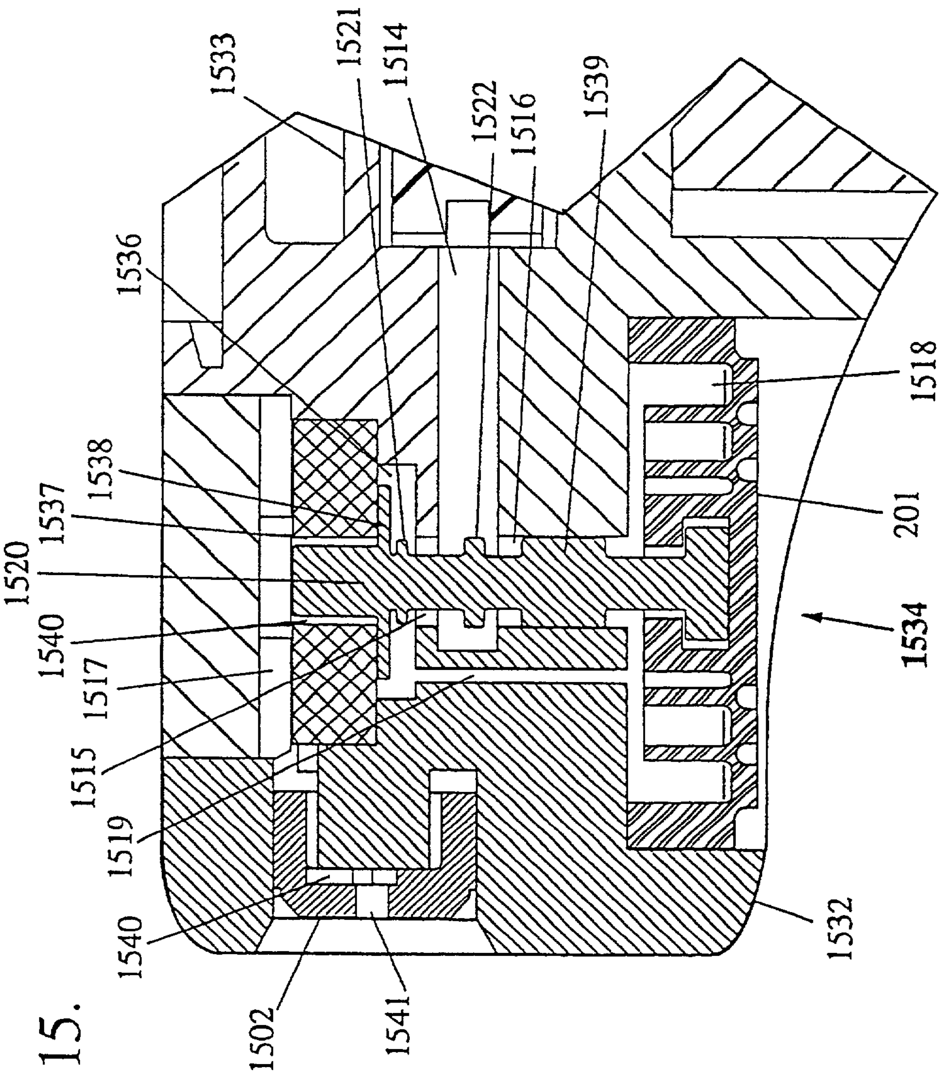
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Fig 15.

Fig 16.

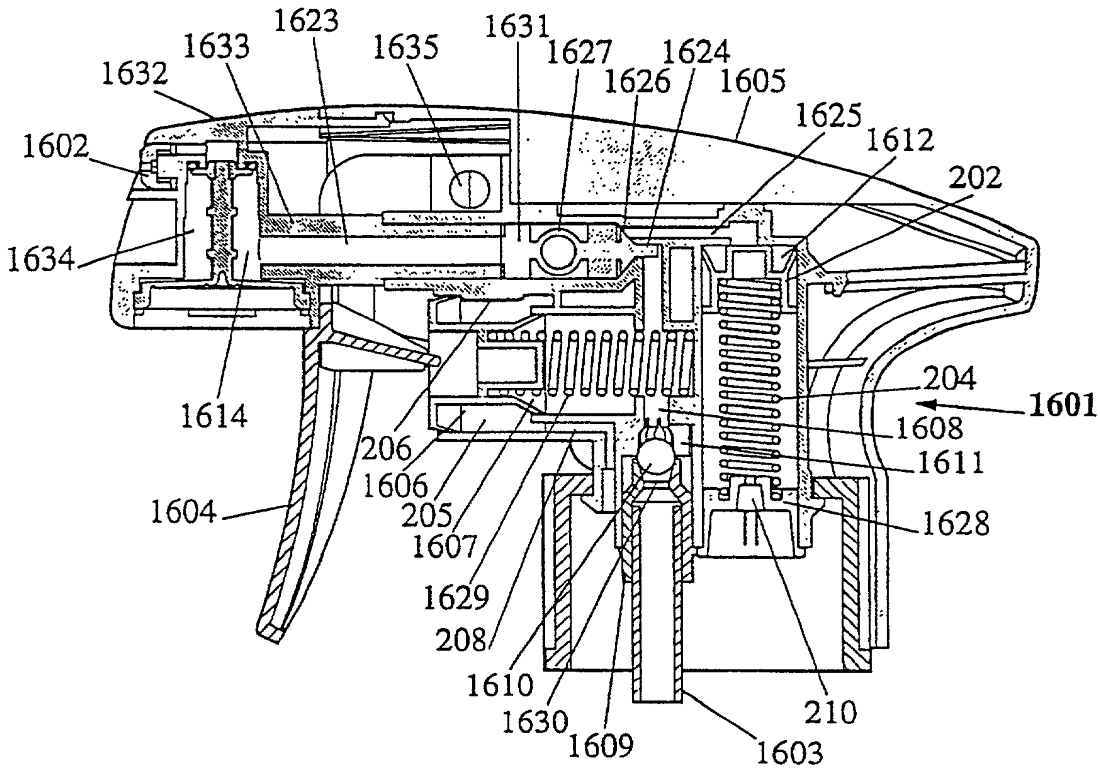
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Fig 17.

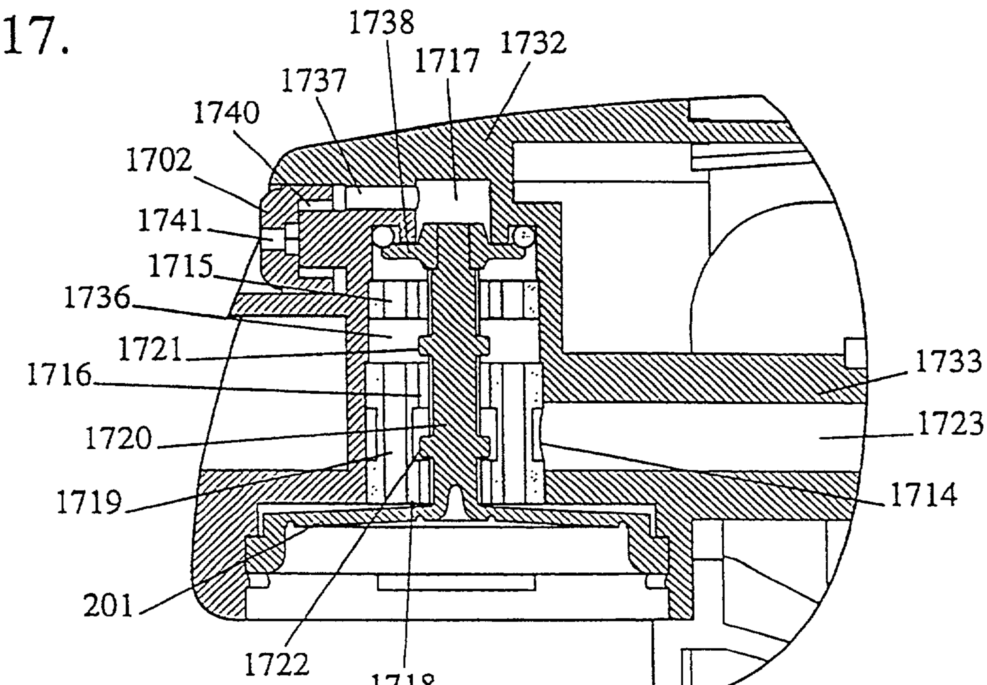
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Fig 18.

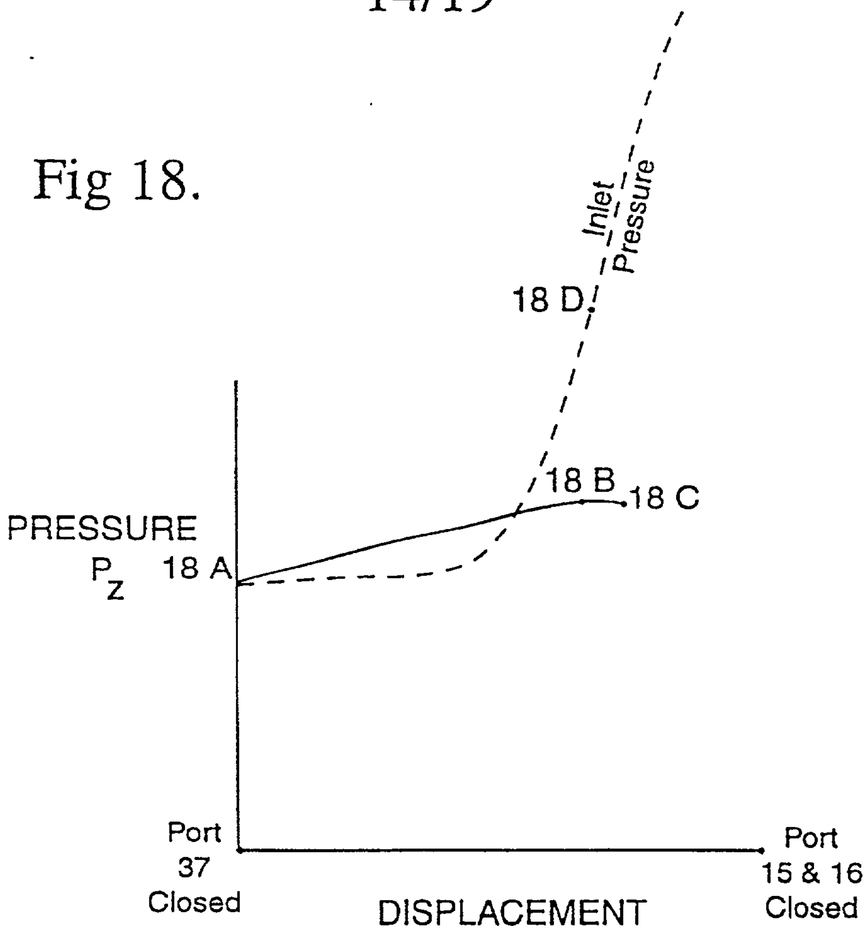
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Fig 19.

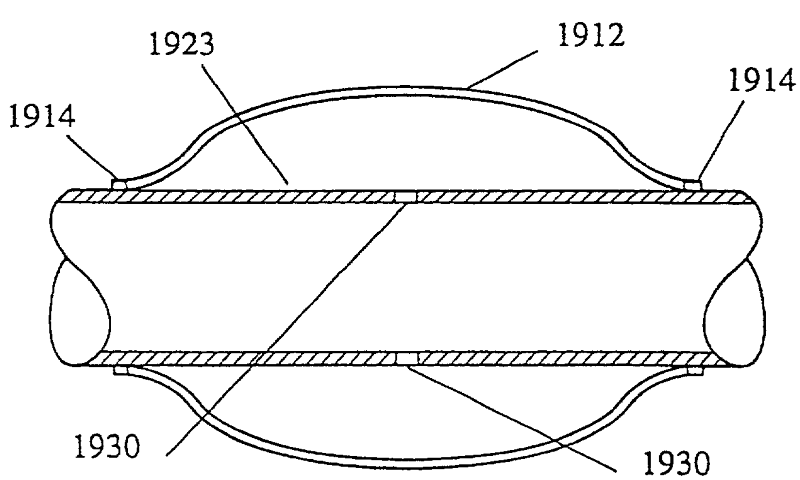
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Fig 20.

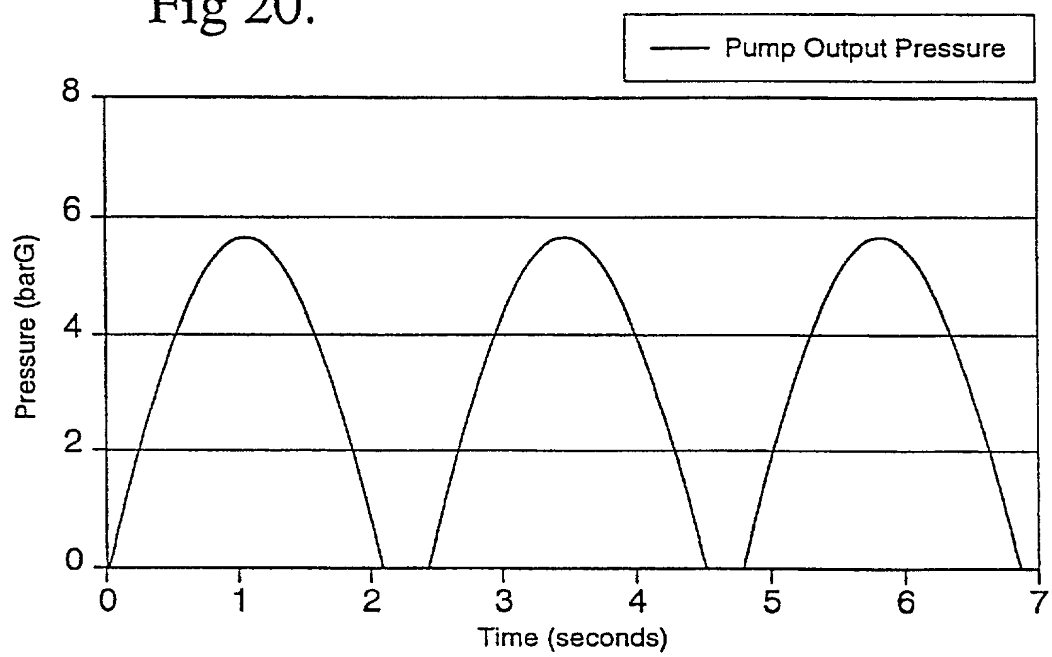

Fig 20a.

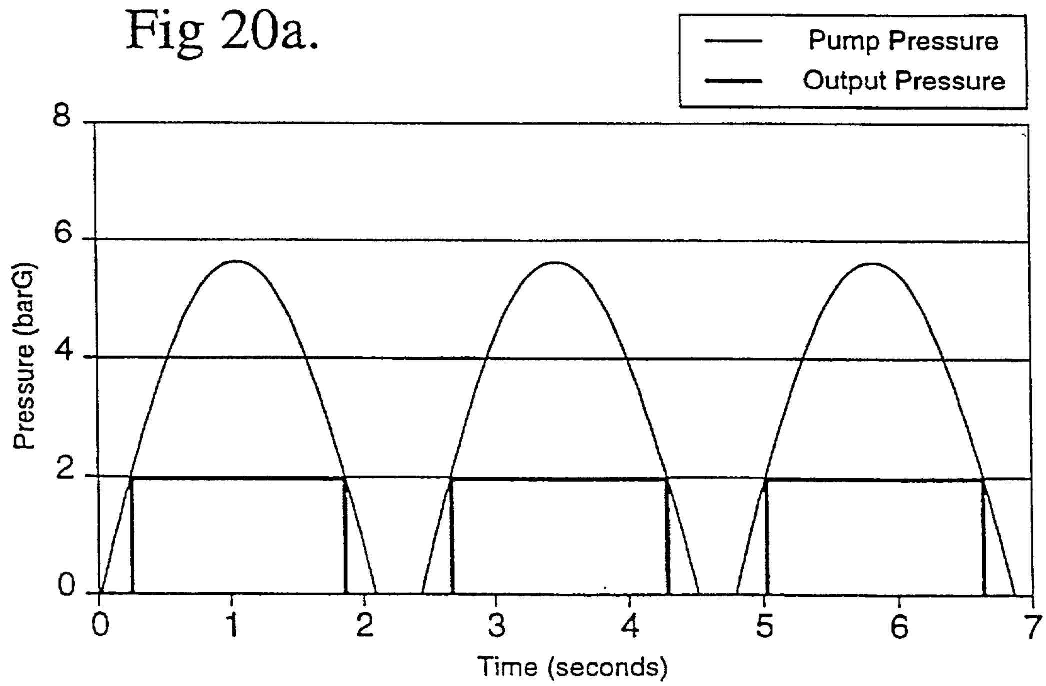

Fig 20b.

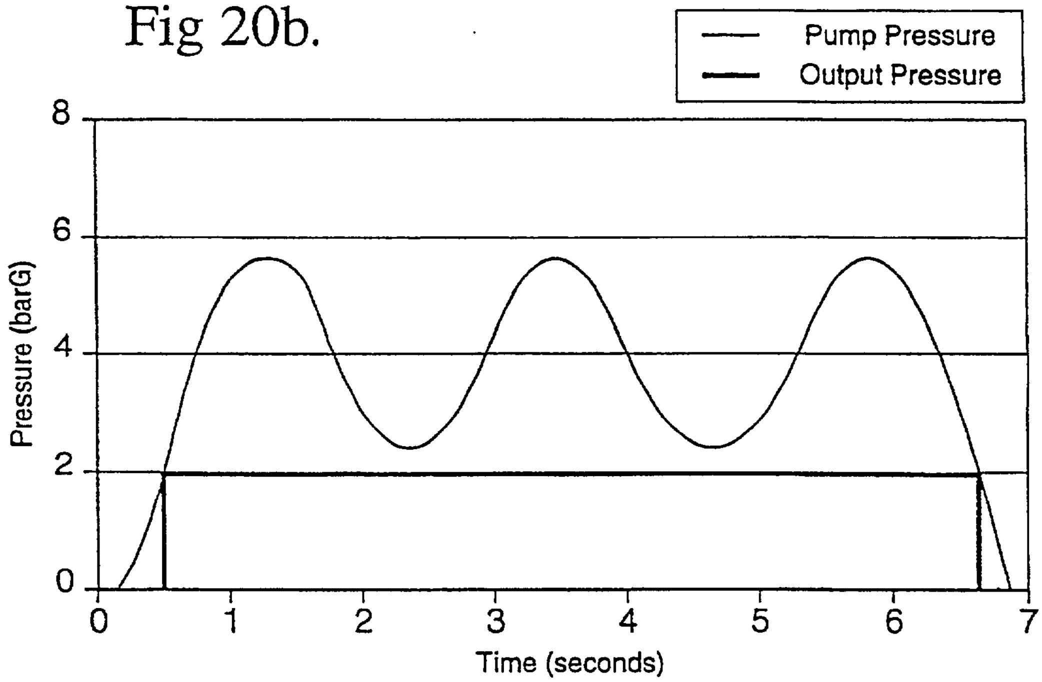

Fig 21.

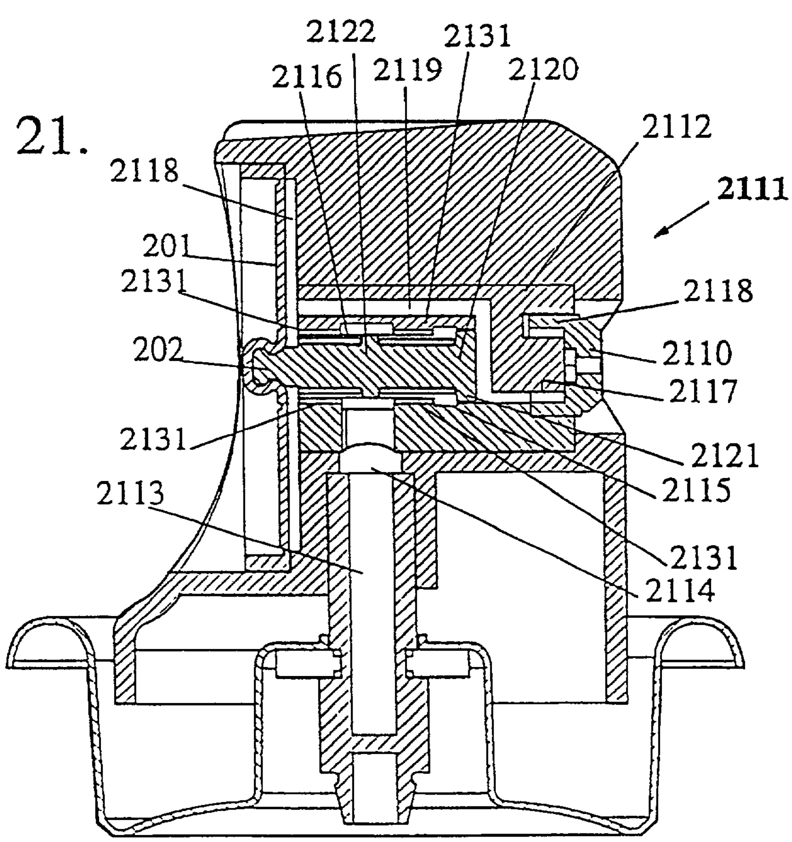

Fig 22.

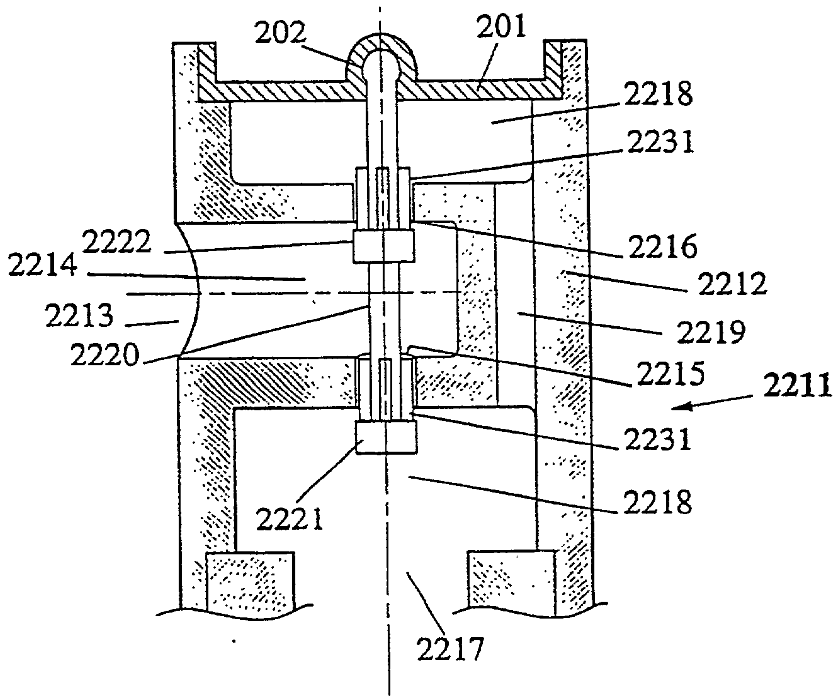

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Fig 23.

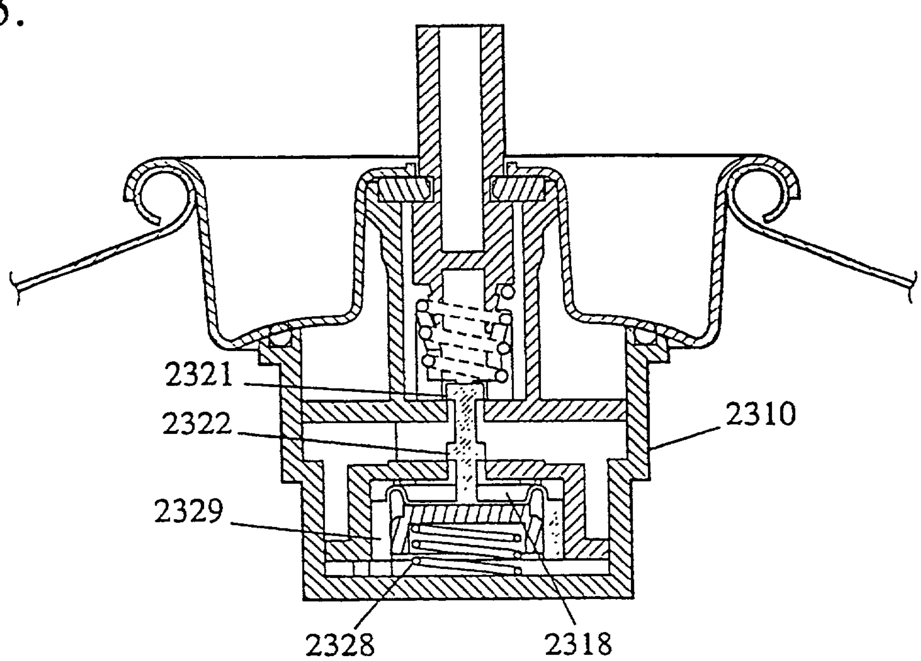

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Fig 24.

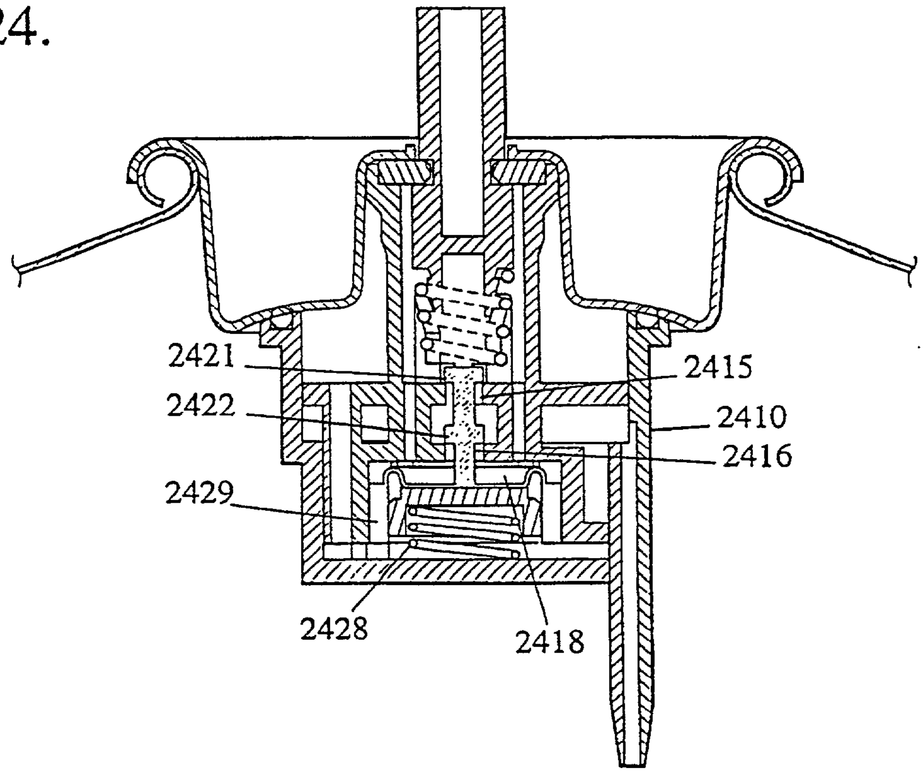
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Fig 25.

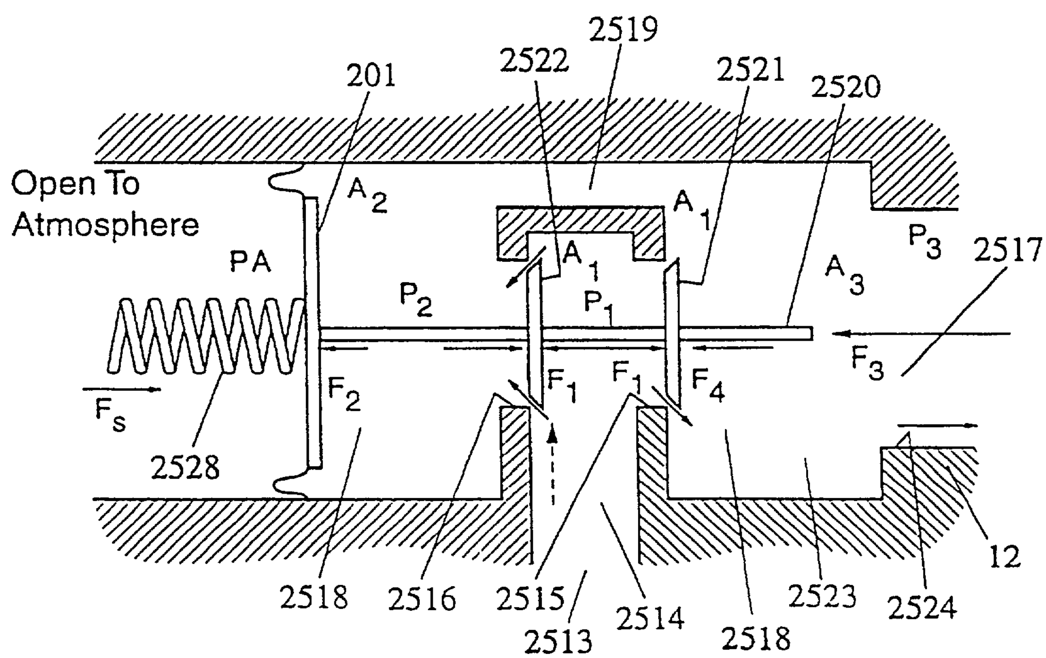
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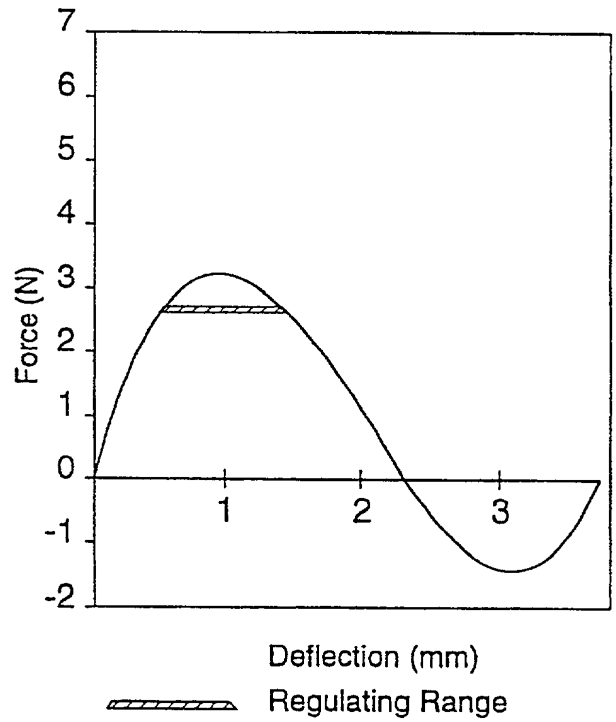
Fig 26.



DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

Attorney Docket No. 9083-6

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled, ***FLUID REGULATOR AND IMPROVEMENTS RELATED THERETO***,
the specification of which

☒ was filed on filed on April 9, 1999 as PCT International Application Number PCT/AU99/00263

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37 Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate, or of any PCT International application having a filing date before that of the application on which priority is claimed.

PP 2907	AU	04/09/1998	☒ Yes ☐ No
Number	Country	MM/DD/YYYY Filed	Priority Claimed

PP 2908	AU	04/09/1998	☒ Yes ☐ No
Number	Country	MM/DD/YYYY Filed	Priority Claimed

PP 2909	AU	04/09/1998	☒ Yes ☐ No
Number	Country	MM/DD/YYYY Filed	Priority Claimed

PP 2910	AU	04/09/1998	☒ Yes ☐ No
Number	Country	MM/DD/YYYY Filed	Priority Claimed

PP 4117	AU	06/16/1998	☒ Yes ☐ No
Number	Country	MM/DD/YYYY Filed	Priority Claimed

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

None	
Application Number(s)	Filing Date (MM/DD/YYYY)

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) or § 365(c) of any PCT international application designating the United States of America, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application(s) in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application (37 C.F.R. § 1.63(d)).

PCT/AU99/00263	04/09/1999	Published
Appln. Serial No.	Filing Date	Status Patented/Pending/Abandoned

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following registered attorney(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

Customer Number 20792

Send correspondence to: ~~David D. Beatty~~
~~Myers Bigel Sibley & Sajovec~~
~~Post Office Box 37428~~
~~Raleigh, NC 27627~~

Direct telephone calls to: David D. Beatty
(919)854-1400

Facsimile: (919) 854-1401

Full name of (first/sole) inventor: **Trevor Cunningham**

Inventor's Signature: X [signature] Date: X 12/12/2000

Residence: Australia

Citizenship: Australia

Post Office Address: Suite 5, 31 Broadway
Nedlands, Perth
Western Australia 6009 AUX
AUSTRALIA

JOHNSON CONTROLS

Application for Leave of Absence

Return completed form to: **Johnson Controls, Inc.** **Attn:** Benefits Department

ENTIRE FORM TO BE COMPLETED BY EMPLOYEE (Please Print)

Employee Name:	Project: W01/21279 **Patent and Trademark Office**	Social Security No.	Home Telephone No.
Department	Position Job Title	Supervisors Name	
Employment Status ☐ Full Time ☐ Part Time ☐ Temporary		Shift	Hire Date
State Date of Leave:		Return Date:	

A. Reason for Leave

☐ For the birth of the employee's child or for placement with the employee of a son or daughter for adoption or foster care.
Name of Child ______________ Expected Date of Birth or Placement ______________

☐ To care for a spouse, parent or child who has serious health condition:
Name: ______________ Relationship: ______________

☐ Because of employee's own serious health condition: ______________

☐ Other: ______________
(Please explain reason for leave)

Note: if leave is for health condition, complete box B and C

B. All Serious Health Conditions

If the leave requested is based on a serious health condition(either of the employee or a spouse, parent or child), please provide the following information:

Name, address and telephone number of health care provider: ______________

Name of condition: ______________

Health care received (or to be received): ______________

Have you previously missed work due to this same condition? ______________
If so, when? ______________

C. Employee Serious Health Condition: If the leave requested is based on your own serious condition, please complete the boxes below

Date you were first unable to work because of this illness or injury:	Did this accident or illness come suddenly ☐ or over a period of time ☐	Were you or will you be hospitalized? ☐ Yes ☐ No
Was there an illness involved? ☐ Yes ☐ No	If yes, when did the illness occur? ☐ a.m. ☐ p.m.	Was the illness work related? ☐ Yes ☐ No
Was an accident involved? ☐ Yes ☐ No	If yes, when did the accident happen? ☐ a.m. ☐ p.m.	Were you at work when the accident happened? ☐ Yes ☐ No

NOTICE

If the leave requested is based on a serious health condition (either of the employee or the employee's spouse, parent or child), you must have the attending physician or practitioner complete a certification form concerning the serious health condition. This certification form must be submitted to the Company prior to the commencement of the leave unless the serious health condition prevents you from doing so, in which case the form must be provided to the Company as soon as possible after the leave commences. A copy of the required certification form is attached.

Employee Signature ______________ Date ______________

Home Address ______________ City, Sate, Zip ______________

LEAVE APPROVAL

Section Supervisor or Manager Signature ______________ Date ______________

Manager Signature (FMLA/MLOA) ______________ Date ______________

Notes: ______________

Reasons Not Approved: ______________